MAR 2 1922

Vol. XXII No. 3 Whole No. 185

MARCH, 1922

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SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

Founded by C. E. Linebarger

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

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Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1913, at the Post Office at Mount Morris, Illinois under the Act of March 3, 1879

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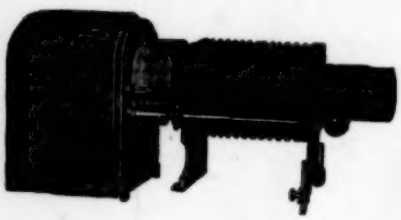

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXII, NO. 3 MARCH, 1922 WHOLE NO. 185

A PRESENTATION OF THE ELECTRICAL THEORY OF VALENCE

By W. H. SEURGIN,

Hyde Park High School, Chicago, Ill.

We have frequently noticed that valences is a variable thing. Particularly have we seen that the sulphur atom in H_2SO_4 has a valence of six; in SO_2 of four; and in H_2S of two. It is now necessary to develop a theory of valence which will account for such a wide variation as this. That electricity is intimately concerned is evident when we recall that acids, bases, and salts, in solution are all found to dissociate into two or more ions which carry positive or negative charges, as shown by the fact that they can be sifted out by passing an electrical current through the solution. But this tells us nothing about what holds together a molecule of SO_2, for example, which does not dissociate, and cannot be electrolyzed. We must first understand something of the nature of electricity.

As early as 1879 Sir William Crookes discovered what we now know to be negative elecricity, but it remained for J. J. Thompson to prove in 1899 that this negative electricity consisted of hosts of tiny particles which we now call electrons; and to Professor Millikan, then of the University of Chicago, we owe the most accurate facts as to their size, weight, and rate of motion. They weigh only about 1-1760 as much as the hydrogen atom, but are even smaller than that would suggest, since if the hydrogen atom were magnified to the size of the classroom the electron would be the size of a grain of fine sand.

If we rub a piece of hard rubber with a piece of woolen cloth we find that the rubber now has the ability to attract to itself tiny pieces of paper and to indicate in other ways that it possesses an electrical charge. The woolen cloth also shows a similar capacity. Certain physical tests show further that the rubber has what we call negative electricity; the wool, positive. We

may explain this in terms of the electron theory by saying that electrons in great hosts have left the wool and crowded onto the surface of the rubber. This makes the surface of the rubber electrically negative, while the surface of the woolen cloth is positively charged because its positive electricity has been uncovered by the loss of the electrons which had kept the cloth electrically neutral. If we should now connect the rubber with the woolen cloth by means of a wire or some other conductor of electricity the electrons would flow back to the woolen cloth and both the rubber and the cloth would again be neutral. In fact, all flow of electric current is considered to be a flowing of electrons, or particles of negative electricity, along the wire or other conductor, while the *positive electricity remains stationary*. It is important to keep this last fact clearly in mind during the following discussion. We see, then, that anything is negatively charged if it has an excess of electrons, and positively if it has lost electrons in excess of the number needed to neutralize its positive electricity.

Let us now consider what holds together the atoms of a common substance such as HCl. If we take hydrogen gas and combine it with chlorine gas, both of which are electrically neutral, we get hydrogen chloride gas which is also electrically neutral. If, however, we dissolve this gas in water we have seen that each molecule dissociates into an H ion which is charged positively and a Cl ion which is charged negatively. Obviously the Cl atom with which we started has gained negative electricity, or electrons, while the H atom has lost a corresponding amount. Since the amount of electricity lost by the H atom and gained by the Cl atom is the smallest of which we have any knowledge we are undoubtedly safe in saying that the H atom has *lost one electron* while the Cl has *gained one*. But, we may ask, when did the electron pass from the H atom to the Cl—when the gases combined, or when the molecule dissociated? Our experience with currents of electricity shows us that when electrons move in quantities they create a considerable disturbance; producing heat, as in an electric lamp; or doing work, as in a motor; or creating a general disturbance, as in the case of lightning. We recall that H and Cl combined explosively, while the dissociation was not accompanied by any unusual display of energy. It seems, then, that the passage of the electrons must have taken place when the gases combined, and so we see that even in the undissociated molecule the Cl atom must have had possession

of the electron which belonged to the H atom. The attraction of the positive H for the negative Cl is what held the atoms together.

The H atom has always been found to lose one electron when it combines with any other atom, that is, to have a valence of positive one, so we may safely use it to work out the structure of molecules in which it occurs. In the molecule of water, if each H atom has parted with one electron the O atom must have taken on two, thus, $H^+ \; {}^-O^-$; and since in the vast majority of cases this is true for the O atom we may use it in the same way.

Let us now return to the question with which we started the discussion, that is, the valence of sulphur. If we write the structural formula for sulphuric acid, $\begin{matrix} H\,O & O \\ & S \\ H\,O & O \end{matrix}$, we may start with each H atom having lost one electron to its neighboring O atom, each of which must have taken one more electron from the S atom, uncovering two of its positive charges. The other two O atoms must each have taken two electrons from the S atom leaving it with a total of six positive charges laid bare by the loss of as many electrons, thus $H^+ \; {}^-O^- \quad {}^{+}\!\overline{O}$; $H^+ \; {}^-O^- \quad {}^{+}\!\overline{O}$. Similarly SO_2 may be written $S^{++}_{\;\;\;\;}\begin{matrix}\overline{O} \\ \overline{O}\end{matrix}$. The neutral S atom is conveniently written S°, while H_2S must be written $\begin{matrix} H^+ \\ H^+ \end{matrix}\!\!\overline{S}$. Thus we see that the neutral S atom may lose as many as six electrons or may gain as many as two, which gives it a range of valence from positive six to negative two, a range of eight. There are other less well-known compounds of sulphur in which it shows different valences, but never does it lose more than six electrons, nor gain more than two.

If we examine the compounds of nitrogen we find that its valence may vary from plus 5 in $H^+ \; {}^-O^- \; {}^{+}\!\begin{matrix}\overline{O} \\ N \\ {}^{+}\!\overline{O}\end{matrix}$ in which it has

lost five electrons to minus 3 in $N^{-}(^{+}H)_3$ in which it has gained three; again a total range of eight. Chlorine has a similar range from plus 7 in $H^{+}\,{}^{-}O^{-}\,{}^{+}Cl(^{+}O^{-})_3$ and the perchlorates to minus 1 in $H^{+}\,{}^{-}Cl$. Carbon ranges from a loss of four electrons as in $C(^{+}O^{-})_4$ to a gain of four in $H^{+}{}_3C^{-}\,{}^{+}H$. (Valence in other organic compounds will be discussed later.) That no element has ever been found to have a range greater than eight in its valence is a very significant fact, and one which is of vital importance at a later point in our discussion.

We will now turn to the familiar subject of oxidation and reduction and examine it in the light of the theory we have developed.

When metallic copper combines with oxygen—both neutral so far as electrical charges are concerned—our theory tells us that the Cu atom has lost two electrons to the O atom. We may write the reaction thus; $Cu^{\circ}+O^{\circ}\rightarrow Cu^{++}\,\bar{\bar{O}}$. But we see that exactly the same thing, from the electrical standpoint, takes place when copper combines with sulphur or with chlorine: $Cu^{\circ}+S^{\circ}\rightarrow Cu^{++}\,\bar{\bar{S}}$ and $Cu^{\circ}+Cl^{\circ}_2\rightarrow Cu^{++}\,Cl_2$. In all cases the Cu atom has lost two electrons. Rather than introduce a new term for what is essentially the same sort of reaction chemists have agreed to broaden the term "oxidation" to include all cases of loss of electrons. We must now define *oxidation* as the *loss of electrons*, and *reduction* as the *gain of electrons*. Since, according to our theory, electrons are lost by one atom and gained by another whenever two elements combine, oxidation and reduction will be seen to be very broad subjects. In the case of the combination of hydrogen and chlorine the H° was oxidized to H^{+} by the loss of one electron; the Cl° was reduced to Cl^{-} by the gain of one electron.

Since an oxidizing agent is one which brings about oxidation, any element which easily takes on electrons must be considered an oxidizing agent—not only oxygen—which is the most common substance used for the purpose, but sulphur and chlorine as well. On the other hand, hydrogen is seen to be a reducing agent, because of the comparative ease with which it gives up electrons.

It must not be assumed that all atoms attempt to hold their electrons, or to gain others; for it is with considerable difficulty that some elements, such as sodium, can be induced to keep those which they have and need to keep them in the neutral, or metallic, form.

With this new definition of oxidation let us return to sulphur. Arranging the compounds which we have discussed in the order of their stage of oxidation, we have the first column in Table 1. S has gone to the limit of its ability to lose electrons. H_2SO_4 therefore has its S atom in the highest possible state of oxidation. On the other hand in H_2S S has gone to the limit of its ability to gain electrons, and is therefore in the lowest possible state of oxidation. What will happen if we mix the two substances? When we bubble H_2S into warm concentrated H_2SO_4 we get a milky precipitate of sulphur. The $\overset{+++}{S}$ has gained electrons at the expense of the $\bar{S}$ being reduced to $\overset{+++}{S}°$, and oxidizing the $\bar{S}$ to S°. H_2SO_4, being at the top of the list, its S atom can only act as an oxidizer, by pulling some other atom up; H_2S, being at the bottom, its S atom can only act as a reducer by pulling some other atom down. What of S° and SO_2 whose S atom can go either way? That will depend on the opportunities. If we heat sulphur with H_2SO_4 we get SO_2, the neutral sulphur losing electrons and acting as a reducer. But if we heat it with copper or iron we get a sulphide in which case the sulphur gains electrons, and acts as an oxidizer. If we heat a mixture of SO_2 and H_2S we find that the intermediate product, sulphur, is formed. This is the way in which much of the sulphur in volcanic regions has been formed.

	S	*N*	*Cl*	*Br*	*I*	*C*	*Cu*	*Mn*
7			$KClO_4$					$KMnO_4$
6	H_2SO_4							
5		HNO_3	$KClO_3$	$HBrO_3$	HIO_3			
4	SO_2	NO_2				CO_2		MnO_2
3		N_2O_3	$KClO_2$					
2		NO				CO	CuO	$MnCl_3$
+1		N_2O	KClO				Cu_2O	
0	S	N_2	Cl_2	Br_2	I_2	C	Cu	Mn
−1			HCl	HBr	HI			
2	H_2S							
3		NH_2						
4						CH_4		

TABLE 1.—SHOWING RANGE OF VALENCE OF CERTAIN ELEMENTS.

The action of H_2S on HNO_3 is particularly interesting, being between the most highly oxidized of the nitrogen series and the lowest state of oxidation of the sulphur series. $\overset{--}{S}$ of the H_2S goes up to S°, $\overset{+++}{\underset{++}{N}}$ of the HNO_3 goes down to $\overset{++}{N}\,\overset{--}{O}$ or $\overset{++}{N}\,\overset{--}{O_2}$, and a precipitate of sulphur and the red gas NO_2 are immediately formed. Gunpowder is a mixture of reducers, C° and S°, with an oxidizer, KNO_3.

Let us consider the reaction of copper with concentrated H_2SO_4.

$$\begin{array}{ccccccc} Cu & + & H_2SO_4 & \longrightarrow & CuO & + & H_2SO_3 \\ & & \overset{+++}{S} & & \overset{++}{Cu} & & \overset{++}{S} \\ Cu^\circ & + & & \longrightarrow & & + & \\ & & \overset{+++}{S} & & & & \overset{++}{S} \\ \text{lose 2} & & \text{gain 2} & & & & \end{array}$$

The Cu° atom loses two electrons which are gained by the S atom. The latter must drop one of the $\overset{--}{O}$ atoms which will combine with the $\overset{++}{Cu}$. The remainder of the reaction consists in the double decomposition reaction between the CuO and more H_2SO_4, the decomposition of the H_2SO_3, and the addition of the two reactions.

In the similar reaction between copper and HNO_3 the Cu° loses two electrons going up to $\overset{++}{Cu}$, the $\overset{+++}{N}$ gains three, going down to $\overset{++}{N}$. Balancing one against the other we see that we must have 3Cu and 2 N (or HNO_3) filling out the reaction with H_2O, and taking 6 more HNO_3 for the 3Cu.

$$\begin{array}{ccccccc} Cu & + & HNO_3 & \longrightarrow & CuO & + & NO \\ & & \overset{+++}{N} & & \overset{++}{Cu} & & \overset{++}{N} \\ 3\,Cu^\circ & & \underset{++}{2N} & & & & \\ 3\ (\text{lose } 2) & & 2\ (\text{gain } 3) & & & & \end{array}$$

So with any oxidation-reduction reaction we need merely balance the oxidized atom against the one reduced.

We must now subject our theory of electrical valence to a more severe test. What holds the atoms of the molecule of H_2, O_2, Cl_2, etc., together? Here we find that chemists are not agreed. Possibly the two available electrons in the H_2 molecule are in the possession of one atom, thus: $H+\ \ \overset{-}{\underset{-}{\ }}+H$. One atom would then be distinctly positive, the other distinctly negative, but which one shall have the electrons? Possibly they are held in common, thus: $H\ \ +\overset{-}{\underset{-}{\ }}\ \ +H$. And, possibly, since

we believe the electrons to be rotating around the axis of the molecule, most of the molecules have the electrons midway between the nuclei of the atoms while in a few they have veered slightly toward one nucleus. This would mean that a few of the molecules would have one H atom slightly more negative than the other. These would be the reactive molecules, and when these were used up others would probably form in accordance with the laws of equilibrium. These would, in turn, be used up, and eventually all of the hydrogen molecules would have passed through this form and been used up. The same argument applies to O_2, N_2, Cl_2, etc.

This furnishes us with an explanation of the bleaching power of chlorine. A solution of chlorine in water contains some HCl as may be shown with silver nitrate. If we consider the chlorine molecules which have the unbalanced structure we see that they would react with water thus:

$$H^+\ {}^-O^-\ {}^+H + Cl^+\ {}^-Cl \longrightarrow H^+\ {}^-Cl + H^+\ {}^-O^-\ {}^+Cl$$

Cl^+ is in an unnatural condition tending strongly to absorb two electrons to make it Cl^-. These it may get from the adjacent molecules of dye, the O atom being then dropped to take the place of the lost electrons in the dye molecule.

Hydrogen peroxide offers another interesting problem. Probably the same argument applies here as in the case of the O_2 molecules, the electrons being held jointly in the majority of the molecules, $\begin{matrix} H^+\ {}^-O \\ -|- \\ H_+\ O- \end{matrix}$ but with a few molecules in which the electrons have veered toward one O atom leaving the other one slightly positive and therefore more likely to absorb electrons from neighboring molecules of organic substances. We should expect hydrogen peroxide to have oxidizing properties similar to oxygen gas itself, but more strongly so because of greater concentration.

The structure of organic compounds has been much argued. One view holds that the corn rs of the carbon tetrahedron may gain or lose electrons independently of each other, so that methyl alcohol would have the structure, $H^+\ \begin{matrix} H_+ \\ -C^- \\ {}^+H \end{matrix}\ {}^-O^-\ {}^+H.$

The more widely accepted view, however, is that the electrons are shared in a manner similar to that which we have already assumed to exist in several cases.

Rather early in our discussion we noted the fact that several elements exhibit a range of valence of eight, but never more. We are now ready to inquire into the reason for this apparently "magic" number.

Mosely, a brilliant young English scientist who was killed at Gallipolis proved that when the elements are arranged in the order of increasing atomic weights, as they are in the Periodic System, the number of positive charges on the nucleus of the atom is just equal to the number of the atom in the list, this relation holding throughout the table if we leave the customary blanks for yet undiscovered elements. Since the atom of every element is electrically neutral, it follows that the number of electrons possessed by each atom must be equal to the number of positive charges. Thus the H atom must have one positive charge on the nucleus and one electron; He, 2+ and 2−; Li, 3; Gl, 4; etc. This much seems fairly certain. Just how the electrons are arranged about the nucleus is open to debate. We shall consider only one theory, that of Lewis and Langmuir, because it is attracting much attention at present and seems to be the most satisfactory theory so far put forth.

This theory assumes that the electrons are arranged about the nucleus in shells like the successive layers of an onion. Let us start with Helium. It has two positive charges on its nucleus and two electrons. Since helium has never shown any tendency to combine with any other substance; that is, to lose or gain electrons, it seems that the first shell of the atom is filled by two electrons, and the atom is stable when this shell is filled. Lithium has three electrons, two of which constitute the inner shell, while the third starts a second shell. The other elements of the first series run as shown in table 2, ending with Fluorine which has seven electrons toward the second shell. But when we add one more positive charge to the nucleus and one more electron we have Neon, which exhibits the same inability to gain or lose electrons as did Helium. Evidently, the second shell has been completed, eight electrons being the number necessary to fill it. We may go through the second series in the same way, this time building up a third shell, also of eight electrons. The fourth shell holds eighteen electrons, comprising the first long series in the periodic system. If we assume that the distance of the second shell from the nucleus is twice that of the first its area will be four times as great and it will hold four times as many electrons. The third shell is assumed to be superposed on the

second. The fourth shell is three times as far from the nucleus as the first, nine times as great in area, and holds nine times as many electrons.

Now, let us see how this applies to the valence and chemical nature of the elements. The atom of any element is most stable when it has a full shell of electrons and no extra ones. Lithium and sodium may reach that condition in two different ways, either by losing the one extra electron, or by gathering in seven more. The latter seems to be too big an undertaking, so each element shows a very strong tendency to lose the extra one which gives it a valence of one. We must remember that the nuclei remain unchanged during ordinary chemical reactions, which keeps lithium and sodium from being identical with helium and neon, respectively, after the loss of the electrons. At the other

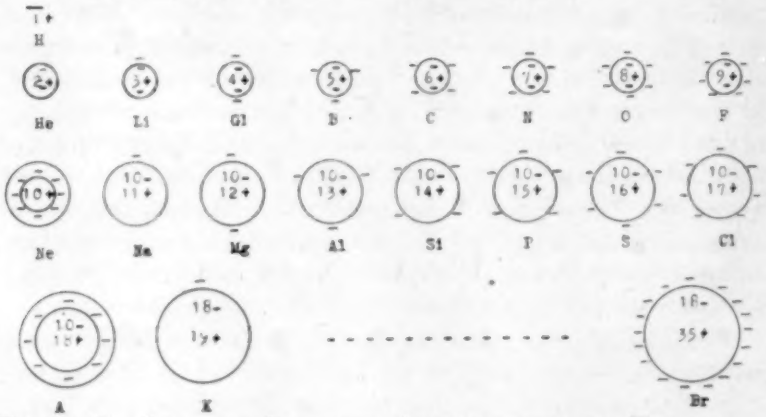

TABLE 2.—SHOWING SUPPOSED ARRANGEMENT OF ELECTRONS ABOUT NUCLEI OF ATOMS.

end of the series we find fluorine and chlorine, each looking for one electron to complete its collection. What more natural than that sodium, with the extra electron, should be just the atom to supply chlorine's deficiency of one? On the other hand chlorine can reach a similar stable condition by losing its seven electrons and getting down to the second shell as it does in the perchlorates. Hydrogen, except in very few rare compounds, loses its one electron, rather than take on another one. Sulphur, we find, has six electrons toward the third shell, all of which it may lose, as in SO_3, or to which it may add two, as in H_2S. Carbon may lose four or gain four. The valence of an element depends only on the electrons in the outer shell, those of the inner, completed, shells never taking part in ordinary chemical reactions.

THE TEACHING OF PLACE GEOGRAPHY.[1]

By Douglas C. Ridgley,

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There can be no geography without place relationships. There can be no history without place associations. Current news cannot be read understandingly without some knowledge of places and their present-day significance. The mere location of places, however, does not constitute geography. It is only one phase of geography teaching, and that a subordinate one. Places, if learned intelligently, are learned through association of ideas. It is the interesting and valuable facts and relationships associated with places that make the places worth being learned.

A journey lesson filled with concrete images of places, with pertinent geographical facts concerning each place while it is clearly in consciousness, will do much more than drill exercises alone to fix permanently in mind certain places along the journey. A journey lesson conducted by a fifth grade teacher consisted of a trip from the home town eastward to Japan, travels throughout the Japanese Empire, and another long eastward journey across the Pacific and the Homeland to the starting point. Pictures, globe, maps, atlas, textbook, supplementary readers, railroad folders, steamship booklets, and other sources of information were used in gathering actual facts.

The journey proceeded from day to day for five weeks. Each pupil wrote his own story of the journey as the work continued. The result was individual booklets, each containing a geographical essay in good English with more than fifty place names properly used. No effort had been made to teach the names of places, but the names of many places were necessary to the definite travel experiences enjoyed by these young travelers. Each day, they talked of the places previously visited as if they had been there in person. They were ready to move forward and to learn of new places.

A high school class in physiography using one of the standard textbooks showed that they knew the location of the many places mentioned in the text only in a dim and distant way. Various methods were used to aid them in developing a clearer sense of location. If the places of each day's lesson were located in class, it was found that so much time was consumed in this

[1]Read before the Geography Section of the C. A. S. and M. T. at Soldan High School, St. Louis, Mo., November 25.

work that the development of the regular lesson was greatly hindered.

So great was the need of this class for a keener sense of place relationships that it seemed necessary to devote an entire lesson from time to time to the study of places. An ability to use maps intelligently and to visualize actual locations on the earth was clearly needed. The special lessons on places were centered on a study of those places named in the next chapters in advance in the textbook. One method of study required the rapid scanning of the pages for names of places. Each pupil made out a table. In column 1, he wrote the names of places not previously studied; each name was to be followed by the name of the state or country in which the place was found. In column 2, the fact or relationship for which the place was mentioned was briefly indicated. Each place thus listed was to be found on a map in the textbook or elsewhere. The work for the assigned lesson was to proceed as far in the text as time of preparation permitted. The recitation period was spent in comparing lists, finding places on the wall maps, and relating the places to the topics of physical geography involved.

A single lesson of this kind should cover the ground of several textbook lessons to follow. The time has been used to the direct advantage of the pupils. The rapid scanning of the pages has given a suggestion of the scope of the work treated. In the succeeding lessons, the pupils read the text more rapidly and with keener understanding, and they are better able to visualize the physical geography because of a definite knowledge of the place relationships.

Place names are even more numerous in the study of commercial geography than in physical geography. Unless students are given aid in mastering the vital place relationships of industry and commerce, much of the value of the study has been lost. By constant use of the maps of the textbook, atlas, and wall maps as a part of the daily preparation and recitations, the important and vital place relationships are mastered.

Exercises are needed also to enable pupils to think these places out on the surface of the real earth. Too often, the knowledge of places is limited to their place on the map, without the ability to translate the map into concrete visual images of the real earth. This may be done in connection with the map study by requiring pupils to point in space towards important places and to estimate their distance in miles.

As an occasional review lesson in commercial geography, an exercise may be centered on commercial centers. The teacher may give a list of twenty-five or more places which have occurred thus far in the study. Or, each pupil may be left free to select twenty-five or more places which he thinks important. With these place names in column 1 of a table, column 2 may be filled out by entering as many facts of geographical value as can be found in the textbook or elsewhere. In the recitation, a pupil may be required to select any place from his list, locate it on the globe or wall map, then point toward it in space and state pertinent geographic facts about it. An occasional lesson of this kind tends to develop the "atlas habit" and the ability to translate printed matter into terms of actual earth relationships.

In order to be sure that students make steady progress in ability to know places, it is necessary that the teacher develop his own powers of atlas study and his ability to translate map images into actual earth images. There is no more fruitful field in the teaching of geography than an increase in the power of the teacher to develop in his pupils the ability to see place relationships definitely and concretely as a part of the study of geography. The danger lies in assuming that because the places are named in the text and are shown on the maps, therefore, without direct teaching, the pupils learn the places properly. It is the teacher's province and privilege to devise ways and means of teaching places in their proper relationships, and this opportunity should not be neglected.

However, the teacher who is seeking aid in this field of geography teaching may subscribe to the general schemes set forth in the foregoing, and still ask: "What places are worthy of special attention in geography teaching, and how can these places be brought to the attention of teacher and pupil for definite inspection and study?"

While the writer has had years of experience in teaching geography in the high school, he has been interested chiefly in recent years in the teaching of geography in the normal school and the elementary school. Experiences drawn from the field of elementary school geography, however, are of definite value in all fields of geography higher up. The following discussion of the problems of place geography has a bearing on the geography teaching in any school from the elementary school through the university.

A simple test was used to determine whether pupils had ready for use a knowledge of some of the fundamental facts of place

geography. An outline map of the United States without names was placed in the hands of all students of grades 5-8 of the elementary school; all students of the four-year high school; and all students studying geography in the normal school. They were to indicate the names of the states on the map. The results showed that the pupils had not done as well as the teachers had believed they would do. The pupils wanted another trial. The same test given one week later showed decided improvement.

An examination of the situation indicated that in all drill work in place geography on textbook maps or wall maps, pupils were confronted with maps completely labeled. There was no opportunity to test ability to identify places because the excellent maps at hand had already identified every place worth knowing.

This led to the development of ten place maps containing the places suitable for use in the elementrary school.[1] The places are indicated by numbers and letters. No names appear on the maps. A key accompanies each map so that absolute identification is immediately possible. The series consists of two maps each for United States and Europe and one map each for North America, South America, Asia, Africa, Australia, and the World. The lists of places have been submitted to many teachers, and they have uniformly agreed that the places indicated should be known to pupils by the time they have completed their study of geography in the elementary school.

An examination of the series of maps shows that all places indicated may be classified under the following six topics: Political divisions, islands, mountains, inland waters, coast features, cities. The total number of places indicated on each map of the series is as follows: United States, two maps, 131, 116; North America, 97; South America, 75; Europe, two maps, 105, 108; Asia, 124; Africa, 102; Australia and Islands, 68; World, 141 This gives a total of 1,067 for the ten maps. The number of duplicate names is 257. This leaves 810 different places indicated on the series of ten maps.

These place maps may be used as mechanically as the multiplication table without any problems for application. Or, they may be made as interesting as simple problems in mental arithmetic dealing with matters of real interest to pupils. If the study stops with identification of number and name, the work is irksome and of little value. If identification is accompanied by interesting and valuable information, the study, in the hands of a skillful teacher, may be made as fascinating as a game, and a valuable exercise in geography.

[1] NOTE—The set of 10 place maps referred to above may be had of McKnight & McKnight, Normal, Illinois, for 10 cents.

One method of handling a place map as a class exercise of several lessons consists of a journey throughout the land to visit all places indicated on the map. The pupils, under the direction of the teacher, decide on a line of travel from home which shall carry them to each place indicated on the map and back home. The globe, maps of textbook and wall maps, pictures, reading matter of textbook and other sources are used to obtain geographic facts about each place to be visited. The story of the journey may be written out or given orally. It may be abbreviated or extended as seems best adapted to the interest of the pupils and to the time available. It may be accomplished in successive lessons or by an occasional lesson as the general study of the region proceeds. The results depend directly on the teacher's skill, enthusiasm, and personal interest in the work.

Similar work may be done by high school classes in the study of any phase of geography whether physiography, commercial geography, or regional geography. Under the teacher's guidance, pupils will select a list of places worth visiting.[1] The journey can be planned by the class and the study kept within the limits of the course of study as outlined. The journey can then be carried on as a means of making realistic the information derived from textbook and other sources.

In conclusion, let it be said that geography is not being taught unless place relationships are made part and parcel of every topic, and, moreover, place geography is not being taught unless each place is directly associated with its geographic environment.

MODERN TENDENCIES IN THE USE OF THE PHYSICS LABORATORY.[1]

By Leslie W. Lyon,

Soldan High School, St. Louis, Mo.

I was very strongly tempted to call my subject "Brass Tacks," but for the sake of clearness it is perhaps just as well that I did not yield to the temptation. I know that in these meetings I am always very happy when the speakers "get down to brass tacks" instead of making vague generalizations, and if I get to generalizing too much I trust that the Chair will remind me of my good intentions.

I wish to say at the outset that the little I have to present to you might, with just as much propriety, be presented by my

[1]Read before the Physics Section of the Central Association of Science and Mathematics Teachers, at Soldan High School, St. Louis, November 26.

colleagues in the Physics Department of Soldan High School, inasmuch as the work is the result of a fine cooperation.

There are certain tendencies in the laboratory end of Physics teaching, which have been apparent for some time. First, there is the constantly increasing use of commercial forms of apparatus for high school work to take the place of strictly laboratory apparatus. I might mention the commercial screw-jack, the block and tackle, both illustrating a tendency to eliminate the nearly frictionless machine from the laboratory and to use in its stead a machine which has an efficiency comparable to machines used in practical work. In this connection we have the substitution of the commercial voltmeter and ammeter for the unnecessarily sensitive galvanometer. The Weston triple range ammeter, for example, with the lowest range 0.1 ampere, is sufficiently sensitive for all high school work and has the very decided advantage of reading in practical units. A commercial gas meter is frequently found in the laboratory, a Bourdon pressure guage, commercial types of water pumps, models of bridges, derricks, and roof trusses, lifting magnets, thermos bottle, circuit breaker, foot-candle meter, and many other devices which might be mentioned.

There has at the same time b en a very marked tendency toward the simplification of apparatus, and the elimination of special set-ups used in one experiment only. Apparatus of a sensitiveness and accuracy far beyond the habits and possibilities of the average user is also fast disappearing. We have long since given up the idea of accurately testing important laws and principles in our high school laboratories. Stock material which is found in every laboratory, such as glass tubing, meter sticks, spring and platform balances, spring wire, resistance wire, rectangular blocks of various material and sizes, standard vessels of various shapes and sizes, porcelain lamp sockets, etc., are being used, together with certain standard rods and clamps, to devise all sorts of experimental apparatus. Apparatus so devised may be very crude in appearance and somewhat inconvenient in construction, but it has the very decided advantage that the pupil is able to see through it and to make his manipulation with intelligence. And this is the big thing in high school work. It is much more important that the pupil see exactly what he is driving at, and exactly how his experiment will help him to "arrive," than it is that he shall obtain a nice tabulation of results with an accuracy of one-half of one per

cent. I do not mean to say that we shall cultivate loose methods of experimentation. The pupil should be expected to get as good results as the limitations of his apparatus will permit, and it is very much worth while for him to see what the limitations of his apparatus are.

Two experiments which we have developed will serve to illustrate this point. First, there is our old friend, the experiment on non-parallel forces. I suppose this experiment has received about as universal attention as any other I could mention. A lantern slide will show you the simple arrangement of apparatus we use, and a direction sheet will give you the detailed method. It may not appear to you that this has any particularly outstanding differences from the conventional experiment, but the point is that, whereas it had always been one of the most difficult and least understood of our list, it is now one of the most successful. The apparatus is not only simplified over the usual arrangement, but is capable of more accurate results, percentages of from three to five per cent being the regular thing using ordinary 2,000 gram spring balances. Another point is that the cases are handled by various methods, the parallelogram method being used in the first case, and the sum of vertical components in the other cases. In the last case one of the forces is in a horizontal direction, consequently having no vertical component, and the weight is therefore supported entirely by the vertical component of the other force.

The other experiment I wish to mention is our experiment on the convex lens, another old standby. In this experiment we had always used a form of apparatus with the lamp as an object fixed in position at the end of a simple optical bench. Now, if you wish to fix in the pupil's mind the various cases of the convex lens, since all distances are taken from the lens, it is the lens and not the object which should be stationary. We accomplished this by making object, lens, and screen, all moveable and independent, and measuring the distances with an ordinary meter stick. At the same time we gave the experiment a little more "go," by using an illuminated piece of movie film for the object in certain cases. The block, with the mounted lamp receptacle, is also used in other experiments, e. g., for the testing of fuse wire and commercial fuses, and for determining the candlepower and efficiency of lamps, in which the block may be turned on its side for determining the vertical candlepower.

Now the fundamental idea behind all this is that it is our business as high school teachers of physics to make sure that the experiments we do in the laboratory actually function in the thinking of our pupils. If an experiment does not really get underneath a pupil's skin, as it were, and make him do some real thorough thinking for himself; if it is mere "busy work" or even perchance "copy work" from some other pupil or a last year's notebook; then, no matter how beautiful the written report may appear, the experiment has failed miserably. Pupils who are capable of obtaining and who do obtain some of the very nicest experimental results frequently do very superficial thinking regarding the basis of the experiment and the reasons for the various steps.

If we, here at Soldan, have made any contribution at all to high school laboratory organization, it is along this line. In the first place, we have a certain fundamental list of experiments, fifteen in each semester, mostly along the traditional lines but with a new point of view, which represent the absolute minimum of laboratory requirement. All pupils begin on the first experiment of a new main division, such as machines, heat, light, etc., at approximately the same time. Pupils always get their own apparatus and materials from the cases, and return it at the close of the period. They are allowed to work in groups of not more than two or they may work individually when there is sufficient apparatus. Each group or individual may work as fast as his capacity will permit. As soon as he gets into the laboratory he begins where he left off the last time, and usually has his apparatus nearly set up by the time the tardy bell rings. He must hand in his completed report of one experiment before he begins on the next, unless the instructor gives him special permission to advance. For the first five or six experiments in the first semester, especially, the pupil must bring his experiment report to the instructor during a laboratory period and talk it over with his instructor. This amounts to a personal conference with each pupil, and I insist that the pupil really understand what he is about before he leaves any experiment. He is frequently sent back to his table to memorize a principle, to read the reference more carefully, to check certain calculations or measurements, or to read the directions more carefully. Later in the semester this personal conference is required only of the pupils who are found to need it most or whose report shows lack of understanding of the experiment.

In all cases of personal conference, the experiment is graded at the end of the conference, and the pupil understands that the grade is influenced by how well he shows up in the conference. It is required also that each pupil have the instructor sign and date his measurements before he takes his apparatus down. These may be recorded on scratch paper and the writing up of the experiment may be done at home, but this signed sheet must be handed in with the finished report.

What are the results of this plan? First, all pupils in our classes are able to set up their own apparatus, using their direction sheets in conjunction with diagrams placed on the board. They develop considerable ingenuity in arranging apparatus, so that, as they come to the more difficult special experiments, they are frequently able to proceed with rather brief oral directions. Second, the number of experiments accomplished varies all the way from a minimum of fifteen up to twenty-five or more per semester, thus providing for a large amount of individual difference, and preventing the best pupils from marking time. The experiments beyond the minimum are for the most part of a practical nature, usually very interesting, and serve as a powerful incentive to most pupils to do their best. Some of those used in Physics I are the use of pressure guages, the siphon fountain, a study of pumps, the commercial screw-jack, the phonograph, horsepower of a steam engine. In the second semester we have model hot water and steam heating systems, hot water tank, fireless cooker, thermos bottle, gas stove, making microscope, telescope, and opera glass, an experiment on the camera, finding resistance by more advanced methods, making a rheostat and electric heater, testing a circuit breaker, and the study of a transformer. Third, we succeed in making the laboratory work in physics a real, vital, and helpful part of the course, in fact, the rest of the work is built on the experimental work to a very large degree. We are getting, to a much greater extent than before, a real independence of thought on the part of a large number of pupils.

In short, it seems to me that the result represents a practical combination of the advantages of the project method with a consecutive progress in a well ordered course. The special experiments beyond the minimum represent true projects which may or may not originate with the pupil. It is possible, without great expense, to provide rather fine pieces of practical apparatus for these experiments as comparatively few people are working

on them at the same time, and duplication is not necessary. The expansion may be gradual. New experiments are added each year to the list of possibilities. Let me say here that the little book of Projects in Physics by Frederick Good recently published is especially suggestive along this line.

In conclusion, I would call attention to the further result of this sort of laboratory organization. It prevents the instructor from "going stale." In the large city system of schools this is of great importance. The long tenure of teachers in such systems makes it very easy to crystallize the work in a certain form and then leave it that way. A teacher's enthusiasm begins to go down as a result of this process, and with it goes the enthusiasm and interest of the pupils. Now in order for the teacher to be able to handle this sort of a program, he must develop direction sheets for the required experiments that will actually "get by." And the only test of whether or not they "get by" is the test of actual experience in the laboratory. Our direction sheets are mimeographed and are under constant revision in the light of the questions asked by the pupils and the reactions obtained from them. This by itself is a very interesting experiment in educational psychology. The development of new project experiments also tends to keep the teacher alive and alert, and may give him a great amount of pleasure and satisfaction. If the teacher finds time in the laboratory to hold personal conferences with pupils handing in experiments, to check out special pieces of apparatus, to answer questions, to sign original measurements, and to give some supervision to the people who may need it, he must organize each laboratory division very effectively, and he must develop a considerable degree of personal efficiency.

To summarize: We must introduce into our laboratory the interesting practical experiment, and the very real values of the project method of teaching. We must not, however, drop out entirely those simple experiments which serve to make clear and drive home the great principles on which our science rests. It is more important that a pupil "see through" an experiment, than that he get a beautiful set of data. Some experiments, at least, should make the pupil do some very thorough thinking. The successful combination of the above principles in actual practice will tax a teacher's power and ingenuity to the utmost, and under these conditions he cannot "go stale."

HUMIDITY INDOORS

By John C. Packard,
High School, Brookline, Mass.

The subject of humidity, as treated in the average school course, fails to get into the mind of the pupil, as a practical subject, for two reasons: First, because it is usually taught in connection with the weather, over which man has no control; and second, because the weight of water vapor in the air is usually expressed in "grains," an unfamiliar unit, rather than, in grams, or in ounces.

What we really need to know, for use in the study of household ventilation, is how to find correct answers to the following questions. How much water vapor is there in my room at present? How much should be added to make the room comfortable and healthy? How can I add it? As an aid to the solution of the problem, the following table is submitted.

Absolute Humidity.

Weight, in grams, of water vapor required to saturate 100 cu. ft. of air space at various temperatures:

t.	63	64	65	66	67	68	69	70	71	72	73	°F.
w.	41	43	44	46	47	49	50	52	53	55	57	g.

It is assumed that the pupil has been taught to find relative humidity, by the use of the wet and dry bulb hygrometer, or in some other manner, and that the temperature of the room is known.

To make use of the table:

Problem 1. The dimensions of our physical laboratory are 50 ft. by 24 ft. by 12 ft. How many grams of water vapor are actually present in the air space of the laboratory when the relative humidity is 35% and the temperature of the room is 68° F.?

Solution. Under t, 68°, find w, 49g, the saturation constant at the given temperature. Then 35% of this amount, or 17.1 g. of water vapor, is actually present in each one hundred cubic feet of the air space referred to. But there are 14,400 cu. ft. of air space in the laboratory. Then, $14{,}400 \div 100 \times 17.1$g. represents the total weight of the water vapor in this air space, or, *2462.4 grams, Ans.*

Measure out this amount of water in a dish.

How many quarts are there?

Problem 2. How many grams of water vapor must be added, by evaporation or otherwise, to the air space of the laboratory in problem 1 to bring the relative humidity up to standard?

Solution. Physicians tell us that a school room should have a temperature of from 65 to 68° F. and a relative humidity of from 50 to 60% for the best work. Let us take 55% and 68°. Then, since the relative humidity is given as 35%, there must be added 20% of 49 g., or, 98 g., to each 100 cu. ft. of the air space in the room. The total amount to be added will therefore be $14{,}400 \div 100 \times 9.8$ g., or *1411.2 g, Ans.*

Measure out this amount of water in a dish. How many quarts are there?

Problem 3. The total air space in the living room of my home measures 1200 cu. ft. The air is changed completely three times in an hour. How much water must be evaporated, every hour, to maintain a relative humidity of 55%, at a temperature of of 70° F., when the air admitted through ventilation has a relative humidity of 22% at the same temperature? (Express the answer in quarts.) Note. No account is here taken of the relatively large amounts of water vapor added by the respiration of the occupants of the room.

Experiment with various devices for adding moisture to the air, found in the market, or suggested in the press, and report upon their effectiveness.

What is to be said as to the utility of the water pan found in the average hot-air furnace?

GAMES AND PLAY FOR SCHOOL MORALE.

It is always difficult for a layman to decide just what games are best suited to children at their various ages. The problem is, of course, to get something that will be interesting enough to capture the attention of the child, and which will bring into play the characteristics peculiar to the particular period of life in which he is.

"Games and Play for School Morale," arranged by Mel Sheppard and Anna Vaughan, will appeal to all who have charge of the recreation hours of children, whether in the schoolroom or on the playground. The games are graded—from purely imaginative ones for small children, to volley ball, Hindu tag, and Indian club wrestling for the eighth grade groups. All are simply and concisely explained.

The most satisfactory feature of the booklet is that only a very small percentage of the games in it need any sort of apparatus.

The booklet is published by Community Service (Incorporated) One Madison Avenue, New York, and may be secured for twenty-five cents a copy.

The last section is given over to group games for adults. Anyone who has ever had charge of a school or community social realizes that it is not an easy task to find sufficient games to fill an evening with simple amd wholesome entertainment conducive to sociability. The thirty games described will prove a boon to harassed club hostesses and school workers.

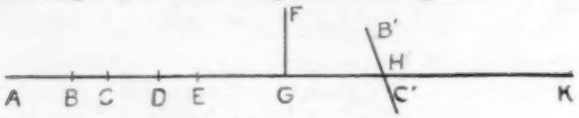
THE FOURTH DIMENSION: AN EXPLANATION THE GEOMETRY CLASS CAN FOLLOW

By Jos. V. Collins,

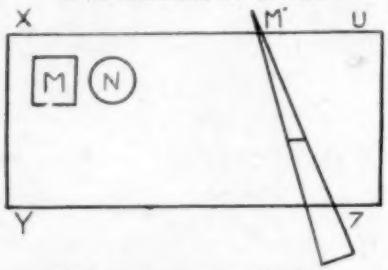
State Normal School, Stevens Point, Wis.

A diversion for the geometry class, is needed now and then, and the Fourth Dimension furnishes one topic, being popular at this time. Articles on the Fourth Dimension almost invariably lead the reader on, making him think he understands, yet repeatedly waking him up to the fact that he does not understand at all. Now a presentation of the subject can be made, resembling the taking off of an aeroplane, in which the machine runs along on *terra firma* for a considerable time, and then suddenly shoots into the air to rise to any height desired. The following explanation undertakes to make the subject quite clear—certainly up to the taking off place.

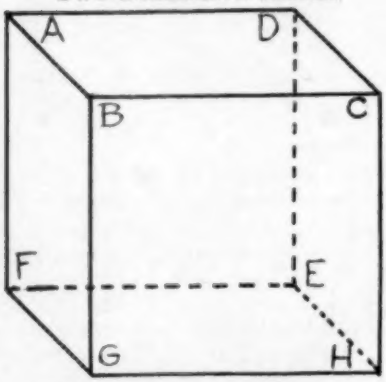
The three figures needed are given at this point.



One-Dimension Space.



Two-Dimension Space.



Three-Dimension Space.

Let AK be a space of one dimension having either no width and thickness or infinitesimal width and thickness, and let BC and DE be bodies or beings in it. Let also FG represent a perpendicular to AK. Similarly, let XYZU represent a space of two dimensions, and let M and N be bodies or beings on XYZU. Also let C (cube) represent a body or being in space of three dimensions.

We will consider: First, some of the more important positive properties of spaces of the first four dimensions; second, some negative properties of these spaces; and third, some relations of each to the next higher space.

I. Positive Properties of the Several Spaces.

1. *Generation of spaces.* Space of one dimension is generated by a point in motion in a straight line; space of two dimensions by a line in motion moving parallel to itself in a plane, as xy. Space of three dimensions is generated by a plane in corresponding motion; space of four dimensions is generated by a solid in motion.

2. *Dimensions.* Space of one dimension has length only; space of two dimensions has length and breadth, perpendicular to each other; space of three dimensions has length, breadth, and height, all perpendicular to each other; and space of four dimensions has length, breadth, height, and ——— (last one not named), each perpendicular to the other three. This last dimension is out of our experience. We know nothing of it from our senses.

3. *Location of Points.* In 1-space a point is located by one ordinate; in 2-space by two coordinates, x and y, in the usual graph manner; in 3-space by three coordinates, x, y, z; in 4-space, by four coordinates x, y, z, and u; and, in n-space, by n coordinates.

4. *Division of Space.* A point divides 1-space into two infinite portions; a line of infinitesimal or no width and thickness divides 2-space into two infinite portions; a plane of infinitesimal or no thickness divides 3-space into two infinite portions; and, a solid of infinitesimal or no thickness in the fourth dimension direction divides 4-space into two infinite portions.

5. *Rotation.* A straight line in 1-space can not rotate about a point; a body in 2-space, as M or N, can rotate about a point; a body in 3-space can rotate about a line; a body in 4-space can rotate about a plane; and a body in 5-space can rotate about a solid.

6. *Motion of Translation.* A body in 1-space can move in only one direction (though in two "senses," positive or negative); one in 2-space in two directions, as east and north, or any combination of them; a body in 3-space in three directions, as east, north, and up, or any combination of them; and a body in 4-space can move in four directions, including the fourth dimensional direction, or any combination of them.

7. *Rigidity.* A body in 1-space is fixed in position by fixing only one point in it; a body in 2-space is fixed by fixing two points in it; a body in 3-space is held rigid by fixing three points not in the same straight line in it; a body in 4-space is held rigid by fixing four points in it not lying in the same plane.

8. *Boundaries.* Points could be fixed at any two points in 1-space, as at A and G, beyond which BC and DE could not go; in 2-space a ring could be put around M or N outside of which they could not pass; in 3-space walls could be built in the shape of a closed box out of which a being could not go, thus constituting a prison for it.

9. *Projection.* Projection in 2-space is well understood. A body in 3-space can be projected on a plane by drawing perpendiculars from every point of it which it is desired to locate to the plane. A body in 4-space can be projected on six planes, viz., XY, XZ, YZ, XU, YU, ZU, the first three of which are the reference planes of 3-space.

II. Negative Properties of the Several Spaces.

1. *Non-Reversibility.* A body in 1-space can not reverse itself. Thus, AB can not turn itself around so that A is to the right of B. Similarly, a body, as M or N, can not be folded over, or reversed, so that its under surface becomes its top surface. Then, in 3-space, a closed body (as the cover of a ball) can not be turned inside out without tearing. A glove can be turned inside out, but that is because it is not a closed surface.

2. *Apparent non-existence of a higher space.* We may imagine the beings in 1-space living in a thread like hole running lengthwise through a straight iron pipe. Clearly such beings would have no conception whatever of other dimensions, because such space would be wholly without their experience. In like manner beings in flatland, like M and N, would have no knowledge of our space, and we would have no knowledge whatever of space of four dimensions. It would be wholly without our experience, and we would think it did not exist.

3. *Apparent non-existence of perpendiculars.* This is evident

from the preceding. It should be noted carefully that the perpendicular in 3-space is perpendicular to all the lines through its foot in a 2-space. It follows then that the perpendicular in the fourth dimension direction is perpendicular to all the planes and lines through its foot of 3-space.

III. Relation of Spaces to Higher Spaces.

1. *Disappearance.* Bodies can disappear from one space and become non-existent to other beings in that space by simply going into higher space. A body in 3-space becomes non-existent to beings in this space by merely dropping out of 3-space into 4-space.

2. *Reversibility by going into a higher space and then returning.* Thus AB in 1-space by dropping out into 2-space and then returning can reverse itself. In 1-space if AB knew of 2-space, he could reverse himself so that DE would see AB's head where his feet had been, to DE's great astonishment. Then, in 2-space, M can move out of the plane it is in, fold itself over and go back into its old space with its under side becoming its upper side, an impossibility from the standpoint of N. Then, also, an object in 3-space can drop out into 4-space, turn itself inside out and then return into 3-space in this form!

3. *Boundaries do not hold.* In 1-space if AB knows of 2-space, he can go into it and thus get out of prison formed by points A and F, and return to 1-space outside of A and F. In 2-space M can get out of the prison ring around him by going into 3-space and then returning to 2-space outisde of the ring. Similarly in 3-space, a body can get out of prison walls not by going through them, but by going into 4-space and thence returning to 3-space outside the prison walls.

Similarly knots tied in 3-space being taken into 4-space can be untied and then brought back into 3-space, since any part of the cord in 4-space can pass through any body enclosing it.

4. *Sections.* If BC in 1-space knows of 2-space he can place himself across this space in the position B^1C^1. Then the point H only can be seen in 1-space. Similarly if the being M^1 places himself across his space, then only that part of him in 2-space can be seen in this space. If M^1 moved across the space, he would appear to change in size and shape as he moved. In like manner a body in 4-space could show only a section of itself in 3-space, and this body would change in size and shape as it moved across the 3-space.

5. *Visibility, tangibility, and permeability of objects.* A being

out in 2-space can see all of 1-space, and can reach any point of 1-space. A being out in 3-space can see every point of 2-space, and can reach any point of 2-space. A being in 4-space can see through 3-space, can reach any point of 3-space, whether inside or outside a body, and can go into any point of a body without tearing or injuring that body in any way. Thus, a surgeon could operate for appendicitis without cutting.

6. *Birth, life, death.* Some writers have conceived the idea that living beings come from hyper-space into our space, thus being born; then, live; and, finally, passing out of our space, die. For example, AB in 1-space might come from 2-space into 1-space, live there, and, passing on out, die. Similarly, a being, as M, might come from 3-space into 2-space, thus being born, live, and then, dying, pass on out into 3-space again. A series of heavens has been suggested (as, for instance, those mentioned in the Koran), which could easily be accounted for by referring them to spaces of the fifth, sixth, and higher dimensions.

7. *Elements.* A body in 1-space consists of one line segment and two end points as B and C; a rectangular body in 2-space consists of 2^2 points, 2 of which lie in the original position before their line starts to generate the surface, and one line lies in this position; a cube or rectangular solid in 3-space consists of 2^3 points, 12 lines or sects, and 6 surfaces, o which 2^2 points lie in the generating surface, four lines and one plane lie in this surface.

To get a "cube" in 4-space we must imagine a cube to move in the direction of the fourth perpendicular a distance equal to one of its edges. Then, there will exist 2^4 points, that is, the eight original vertices and 8 more in the new position of the cube. There will be 32 edges to this figure, obtained as follows: There are four edges at each vertex, the fourth being in the fourth dimension direction. As there are 16 vertices, that will give 16×4 edges but each is counted twice, that is, from each end. Thus there are 32 different edges, of which 8 are generated by the 8 vertices in motion, 16 are in section planes, and the other 8 are unimaginable, being in the fourth dimension.

Then, there are 24 surfaces in this fourth dimensional solid, obtained as follows: There are six planes at each vertex, resulting from taking the four edges at a vertex in pairs. Then, since there are 16 vertices, there are 96 planes in all. But each plane is counted four times, that is, once from each corner of

every square. Hence there are 96÷4 different planes. A "cube" in 4-space is bounded by eight cubes whose existence is inferred as follows: A line in 1-space is bounded by 2 points; a square in 2-space is bounded by four lines; a cube in 3-space is bounded by six squares; then a 4-space "cube" should be bounded by eight cubes. Six of these cubes are generated by the six faces of the cube moving the fourth dimension direction. The other two can not be imaged. (Observe how two points of the generator describe two sides of the square, four lines of the generator describe four faces of the cube.)

8. *Regular polyedrons.* There are five well-known regular polyedrons described in solid geometry, three bounded by equilateral triangles, one by squares, and one by regular pentagons. In 4-space it is found there are six regular polyedrons. The "cube," already described, denoted by C_8; C_4 bounded by five tetraedrons; C_{120}, bounded by 16 tetraedrons; C_{24}, bounded by 24 octaedrons; C_{120}, bounded by 120 dodecaedrons; and C_{600}, bounded by 600 tetraedrons. An explanation of how the figures for the number of bounding polyedrons were obtained is not attempted here. Suffice it to say they have all been exhaustively studied, and models of the projection of each on space of three dimensions have been made.

In conclusion, it can be said that Professor Einstein has recently announced that our universe has limits. Evidently, without any consideration of the question of higher spaces, this statement would seem wholly absurd. In the light of the preceding discussion, however, one hesitates to pronounce positively what is the fact. Thus we learn out of such discussions to suspend final judgment on all similar questions. "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy."

READ THE MAGAZINE OF YOUR BUSINESS.

Each issue of every business, class, professional and technical magazine is filled with detailed accounts of ways in which enterprising men are utilizing present-day conditions to make better records than they ever made before. You need to read one or more of the magazines of your business to be well informed. In business, watch you competitors. No individual or concern has a monopoly of all the best brains and methods. Find out what the other fellow is doing—and go him one better. Crowley, 511 East 164th Street, New York City, has issued a valuable 146-page descriptive booklet in which are listed all the leading business, class, professional and technical publications of the country. There are many of our readers to whom such an instructive catalogue would be of service in their business and professional life. It may be obtained free of charge by writing to the publisher.—*Photo-Era.*

THE LAWS OF EXPONENTS.

By Professor Richard Morris,
Rutgers College.

This paper, while not offering anything new, presents a topic that is more than less troublesome to the average student, and in the treatment of the subject will bring something gained in classroom experience.

The author has begun his Freshman class for several years with the study of the laws of exponents. And, he has, with increasing conviction each year, discovered that the students needed this review in gaining a foothold in college work, and he has also learned that the review proved highly valuable as the work advanced into the several topics of algebra.

Mr. Bertrand Russell says in his book, *Introduction to Mathematical Philosophy*, "Mathematics is a study, which, when we start from its most familiar portions, may be pursued in either of two opposite directions. The more familiar direction is constructive, towards gradually increasing complexity; from integers to fractions, real numbers, complex numbers; from addition and multiplication to differentiation and integration, and on to higher mathematics. The other direction, which is less familiar, proceeds by analyzing; to greater and greater abstractness and logical simplicity; instead of asking what can be defined and deduced from what is assumed to begin with, we ask instead what more general ideas and principles can be found, in terms of which what was our starting point can be defined or deduced. It is the fact of pursuing this opposite direction that characterizes mathematical philosophy as opposed to ordinary mathematics. But it should be understood that the distinction is one not in the subject matter, but in the state of mind of the investigator." He continues, "The most obvious and easy things in mathematics are not those that come logically at the beginning; they are things that, from the point of view of logical deduction, come somewhere in the middle. Just as the easiest bodies to see are those that are neither very near nor very far, neither very small nor very great, so the easiest conceptions to grasp are those that are neither very complex nor very simple."

We shall approach the theory of exponents by reviewing some definitions which are important antecedents to the theory. Involution is abbreviated multiplication, as one author states it, so that we shall naturally begin with the notion that the opera-

tion, multiplication, is the fundamental or rather central one. Other operations will be employed as we proceed. Definition: The factors of a quantity are those numbers which when multiplied together produce the quantity. These factors may be letters, the symbols of quantity, or they may be known numbers formed of the digits. If all of these factors are equal, letters or constants, we are confronted with the same problem with which the early mathematicians were faced, viz., to obtain a device for expressing in concise form, the use of the same quantity several times as a factor. It was certainly a stroke of genius that led to the adoption of the exponent as we now use it. Definition: A positive integral exponent is a quantity placed to the right and slightly above a given quantity and indicates how many times the given quantity is to be used as a factor. The author has found it of considerable value to the students to emphasize the two parts of the definition, viz., *position* and *purpose*.

Let me make a brief reference to history. During the sixteenth century and the first part of the seventeenth, mathematicians were employing one device or another to abbreviate the use of the same quantity several times as a factor. Bombelli (1579) writes ☌ ① ② ③ where we now write x^0, x^1, x^2, x^3. Stevin (1585) uses ○ ① ② ③, etc. for the same purpose. Viète (1591) and Oughtred (1631) used Aq, Ac, Aqq to denote A^2, A^3, A^4. Harriot (1631) simply repeated the letters. Hergione (1634) used A_2, A_3, A_4, etc., to meet the need. But it was the genius and influence of Descartes and Newton which gave us the present permanent form of the exponent. Some one has said that this device doubles the life of the mathematician. Whether or not this be actually true, the figure of speech magnifies the great value of the invention. For there is hardly a problem in analysis that does not involve its use. Without this method of condensation, it is more than probable that the field of mathematics would not be so extensive as it is. It is truly a labor-saving device. If we, as teachers, can lead our students to appreciate, in some measure, their mathematical inheritance, we shall have performed no small service.

Using our definitions of *factors* and *exponent*, employing the word *power* as a synonym for exponent, and with the aid of the four fundamental operations, the laws concerning positive integral exponents are developed with logical rigor. Below will follow a statement of these laws. In all that follows, x, y and z are always positive quantities (no other restriction), m and n

are positive integers, and in the taking of roots we shall always mean the positive root.

I. $x^m \cdot x^n = x^{m+n}$. In x^m there are m factors, and in x^n there are n factors. Hence in all there will be $m+n$ factors. Statement: In the multiplication of the same or different powers of the same quantity, the exponents are added.

II. The fraction $x^m \div x^n$ equals x^{m-n} if $m>n$, or $1 \div x^{n-m}$ if $n>m$. The result of cancelling (division) n factors out of the m factors will leave $m-n$ factors in the numerator; or the result of cancelling m factors out of the n factors in the denominator will leave unity for the numerator and $n-m$ factors for the denominator. Statement: In the division of the same or different powers of the same quantity, the exponents are subtracted.

III. $(xyz)^m = x^m \cdot y^m \cdot z^m$. Since the product (xyz) occurs m times as a factor by definition, each of the factors x and y and z is taken m times. That is, the exponent of the product is used as an exponent with each of the factors. Statement: In a power of a product, the power is made the exponent of each of the factors.

IV. $(x/y)^m = x^m/y^m$. The fraction, x/y, occurs m times as a factor by definition. Hence the proof. Statement: In the power of a fraction, the power is made the exponent of both terms of the fraction.

V. $(x^m)^n = x^{mn}$. According to our definition of exponent, in each of the n times that x^m is used as a factor, x occurs m times as a factor. Hence x will occur mn times as a factor. Statement: In a power of a power, the exponents are multiplied.

It is our custom to emphasize very strongly the singular and plural forms of the word exponent in their proper places.

VI. In the proof of $x^0 = 1$, we use law II, the fact that any quantity divided by itself equals unity, and the axiom, quantities equal to the same quantity are equal to each other. Thus $x^m \div x^m = x^{m-m} = x^0$ by law II; $x^m \div x^m = 1$ by division. $\therefore x^0 = 1$ by axiom. While x is a symbol for any quantity, it should be carefully noted that zero is excluded. Statement: Any quantity to the zero power equals unity.

VII. A factor with a negative exponent may be changed from the denominator to the numerator, or *vice-versa*, by simply changing the sign of the exponent. In the proof of this we use $x^m \cdot x^{-m}$ in order to obtain x^0, and then use law VI, which gives $x^m \cdot x^{-m} = 1$. In solving this equation for either x^m or x^{-m}, the definition of a coefficient as one or more of the factors of a

product should be brought into bold relief. The solution depends upon *division* and not upon *transposition*. Many students have not learned that *transposition* is based upon *addition* or *subtraction*, while solving for an unknown with a coefficient is based upon either division or multiplication.

VIII. Meaning of $x^{1/m}$. We will now give to this symbol such a meaning that it shall be consistent with law I. Since unity may be resolved into the sum of m fractions of the form $1/m$, we may write the identity $x = x^{1/m+1/m+1/m}$ to m terms. And since law I is to hold, we get $x = x^{1/m} \cdot x^{1/m} \cdot x^{1/m}$. to m factors. That is, $x^{1/m}$ is one of the m equal factors of x. Definition: The mth root of a quantity is one of the m equal factors which when multiplied together will produce the quantity Using the radical sign, we may also write $x^{\frac{1}{m}}$ in the form $\sqrt[m]{x}$. Thus the 5th root of 17 may be written $17^{1/5}$ or $\sqrt[5]{17}$.

IX. Meaning of $x^{m/n}$. Whatever meaning is attached to this, it must be consistent with law I. The fraction m/n may be resolved into the sum of m fractions of the form $1/n$. Hence $x^{m/n}$ may take the form $x^{1/n+1/n+1/n+} \cdot \cdot \cdot \cdot \cdot$ to m fractions, or by law I, the form $x^{1/n} \cdot x^{1/n} \cdot x^{1/n} \cdot \cdot \cdot \cdot \cdot$ to m factors, or by definition of exponent, the form $(x^{1/n})^m$, or by law VIII, the form $(\sqrt[n]{x})^m$, i. e. the mth power of the nth root of x.

Again, let $y = x^{m/n}$. Then $y^n = (x^{m/n})^n$, by the axiom, equal powers of equals. And $(x^{m/n})^n$ takes the form $x^{m/n} \cdot x^{m/n} \cdot x^{m/n}$ to n factors, by definition of exponent, or the form $x^{m/n+m/n+m/n+} \cdot \cdot \cdot \cdot$ to n terms by law I, or the form x^m by addition of fractions. Hence $y = .(x^m)^{1/n}$ by the axiom, equal roots of equals, or the form $\sqrt[n]{x^m}$ by law VIII. Thus when the exponent is a positive fraction, the numerator denotes a power and the denominator a root. We must not lose sight of the fact that whatever is done in developing VIII and IX, the idea of being consistent with law I is most important.

The remaining six cases are not usually proved in the tests. But let us take a look at them to see how well their treatment agrees with the idea contained in the quotation at the beginning of the paper.

X. In the case of $x^{m/n} \cdot x^{p/q}$ let p and q also be positive integers. We get the form $x^{mq/nq} \cdot x^{pn/qn}$, by forming similar fractions on the exponents, and the form $(x^{1/nq})^{qm} \cdot (x^{1/nq})^{pn}$ by law IX, and the form $(x^{1/nq})^{(qm+pn)}$ by law I, and the form $x^{(qm+pn)/nq}$ by law IX, and finally the form $x^{m/n+p/q}$ by resolving the last exponent into two fractions. Hence statement in law

I also applies to positive fractions for exponents.

XI. Taking the case $x^{m/n} \div x^{p/q}$, where $^{m/n} > ^{p/q}$, we get the form $x^{mq/nq} \div x^{np/nq}$ by similar fractions, and the form $(x^{1/qn})^{mq} \div (x^{1/qn})^{pn}$ by law IX, and the form $(x^{1/qn})^{(mq-pn)}$ by law II, and the form $x^{(mq-pn)/qn}$ by law IX, and finally $x^{m/n-p/q}$ by resolving the last exponent into two fractions.

XII. Consider the case $(xyz)^{m/n}$. This is developed by showing that $x^{m/n} \cdot y^{m/n} \cdot z^{m/n}$ is equal to $(xyz)^{m/n}$. Let $w = x^{m/n} \cdot y^{m/n} \cdot z^{m/n}$. Then we get $w^n = (x^{m/n} \cdot y^{m/n} \cdot z^{m/n})^n$ by axiom, and the form $(x^{m/n})^n (y^{m/n})^n (z^{m/n})^n$ by law III, and the form $x^m y^m z^m$ by law IX, and the form $(xyz)^m$ by the reverse of law III. Hence $w = (xyz)^{m/n}$ by the axiom, equal roots of equals.

XIII. The case $(x/y)^{m/n}$ is likewise developed by showing that $x^{m/n} \div y^{m/n} = (x/y)^{m/n}$. Put $w = x^{m/n} \div y^{m/n}$. Then $w^n = (x^{m/n}/y^{m/n})^n$ by axiom, and equal to $(x^{m/n})^n/(y^{m/n})^n$ by law IV, and equal to x^m/y^m by law IX, and equal to $(x/y)^m$ by the reverse of law IV. Hence $w = (x/y)^{m/n}$ by the axiom, equal roots of equals.

XIV. Similarly, we show that $(x^{m/n})^{p/q} = x^{mp/nq}$. Let $w = (x^{m/n})^{p/q}$. Then $w^q = (x^{m/n})^p$ by axiom and law IX, and equal to $x^{pm/n}$ by law IX, also. Again $w^{qn} = x^{pm}$ by axiom and laws V and IX Hence $w = x^{pm/qn}$ by axiom of equal roots.

XV. We may show that $x^{-m/n} = 1/x^{m/n}$ by the process of law VIII.

Just a word in review. The work started with some familiar definitions and operations, such as factors, exponent, power, the four operations, positive integers, axioms and simple fractions. We proceeded to develop other more general results, and have removed certain restrictions placed upon the exponents at the beginning. The field of application has been broadened so that the exponents may be positive or negative integers or fractions. That is, the student has started from very familiar notions and has been carried forward in the first direction of the two to which reference is made in Russell's statement.

PHYSICAL EXAMINATION FOR NEW TEACHERS.

Good health is necessary for successful teaching, according to the public school authorities of Williamson, W. Va., who require every new teacher to file with her formal application for the position a record of a physical examination by a competent physician. If the record is not entirely satisfactory, another examination is given the applicant by the school physician. This examination is very thorough and is similar to the test given by insurance companies. The school administrators feel that this precaution is a step toward safeguarding the health of the children. —*School Life.*

HALF-LEARNING AND THE WAY OUT.[1]

By Henry C. Morrison,
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Signs are not wanting that the field of higher education is beginning to be stirred by concern for the intellectual interests of students. It may well be. Did you ever receive from your Alma Mater an appeal for money for a distinctly intellectual purpose? You have received many an appeal for the support of athletics, for contributing to the funds for building a stadium, or an athletic field, for an increase of the endowment so that college teachers can be paid larger salaries. To be sure, the professor must not go hungry. Did you ever receive an appeal for funds to build a better college library? Did you ever attend an alumni meeting at which the main topic of discussion was the intellectual interests of the undergraduate body? Did you ever know of an institution which conducted a systematic campaign among its alumni for the purpose of stimulating them to a consideration of the intellectual growth of the undergraduates? You have had some such appeals and have heard of some such enterprises, but they are few.

Now in what I am going to say to you, I am not thinking of the intellectual life of the high school student or the college undergraduate as being a thing which manifests itself in high marks or in research undertakings in the field of pure scholarship. I am thinking of the kind of thing which produces multitudes of people who like to read, to see, and to think about the best things in science, and literature, and art.

I want to suggest, for instance, that there is one kind of measure which can be applied to the teaching of science and mathematics, which is not concerned with the passing of standardized tests or the production of capacities which can immediately be used in earning some one's bread and butter. The evidence of successful teaching at high school or college level which, in my judgment, is worth more than all else, is the successful generation in students, both while in school and afterward, of the desire to read and to keep up in the field in which they have been studying. The high school and undergraduate department of the college is concerned primarily with general education. That means that they are concerned primarily with the production of really educated men and women, individuals

[1]Read before the General Section of the C. A. S. and M. T. at Soldan High School, St. Louis, Nov. 25, 1921.

who will doubtless do their life work in some special field, but who are primarily concerned in getting into intellectual and moral touch with the world in which they must live as men and women, and not merely as bread winners or producers. There is a growing tendency toward a concensus of opinion that, after all, the educated classes in this country need very much more to learn how to live than to learn how to earn a living. The latter is extremely important, without doubt, but it is relatively easy to provide for. Most of the older civilizations of the world found in their time that ability to get a living isn't worth very much without ability to live adequately. I believe that both science and mathematics have an opportunity to contribute to this intellectualizing of the common life of mankind which they ought to realize.

The unpalatable fact is that the educated public of our day, that is, that part of the public which has at some time gone through high school and college, is not greatly concerned with intellectual things. One scarcely ventures to open conversation on the reading of any book above the grade of the most talked of novel, or the latest crude production in history which has happened to catch the popular eye, for fear of being read out of polite society as a high-brow. Is this merely finding fault with a world which is at best an imperfect world? Was it ever any better in this particular regard? I believe it was. I believe that there have been better times in this respect and that there are going to be better times again. There was a time when Ralph Waldo Emerson and the sages of Concord, to say nothing of somewhat less transcendental lecturers, could speak to crowded houses night after night. Across the water there was a time when Tyndall and Huxley and their school could do the same thing. Human nature can't have changed radically in a generation or two.

In other words, I feel that the situation which I am condemning is an episode which is traceable unmistakably to certain causes not in themselves related to the frailty of human nature. In fact, when I hear a teacher deploring the stupidity of his students, their lack of interest in their studies, their concern for other things than those of the mind, I know perfectly well that that teacher is merely operating a defence mechanism, setting up an alibi.

Nothing is better established in education than the principle that what you put into the school of today will tend to

appear in society in the next generation. The converse cannot be stated with any such assurance but, in this case at least, I think it can be stated that a lack noted amongst the educated classes of our own time can fairly be traceable to some kind of a lack inherent in the schools through which they have passed. What is in the school today and what has been there through a large part of our own time?

The outstanding conception of intellectual achievement, which has been nourished, professed, and exalted by the schools, has come to be a mechanistic, statistical conception of intellectual achievement. If you have succeeded in staying in the classroom for a certain number of hours a week for one year you have a unit. Fifteen of these units means that you have reached a milestone in your intellectual career. When you have passed the third of these milestones you are educated. However, you must attain certain grades and marks, wherein lies the fascination for the school administrator. It is a wonderful thing to have these A's, and B's, and C's, and B-'s, and 78 per cents, as they come across the desk into the principal's office or the sanctum of the dean. You can do almost anything with them. You can make graphs of them, and apply wonderful formulas to them, and by and by you become so learned that you go and offer a course in a school of education, on school administration. That these must be interpreted strictly in terms of real modifications in behavior of the individual to have any meaning whatsoever, does not seem to bother their average devotee. His students listen to him, his patrons marvel at him: "if this young man expresses himself in terms too deep for me, what a very particularly deep young man this deep young man must be!"

Let us for a moment think of all this beautiful mechanism, and see just what it means in terms of real achievement and the awakening of intellectual interests.

In the first place, all these wonderful marks are in general given for superiority in getting lessons. Extra credit may be given for getting lessons especially well, but, in the long run, it is a question of getting lessons. How often does the secondary school or college give credit or recognition to the youth who evinces some actual independent capacities to read, to think, to work? We do have those people, but they are generally looked upon by most faculties as being what T. R. would have called "natural-born mavericks" and the lesson-getter of the school looks upon them with scorn. "What infinite folly," he says, "for a fellow to read anything he doesn't get credit for!"

So we have the upper end of our highly efficient distribution—those people who have been steadily increasing in power to get lessons. It can be shown by anybody who chooses to investigate the situation critically that the majority of these people are lesson-getters and nothing else. I say the majority, for occasionally there are amongst them people of real intellectual capacity. More often they are people who never produce anything but lessons, who find their way into graduate schools, who are distinguished for the particular aridity of their imaginative outlook upon the field which they have chosen, and who eventually land in a college chair to reproduce their kind.

What about the rest of the distribution, omitting those unfortunates who don't get into the distribution at all? It is necessarily composed of individuals who haven't quite got their lessons, and of other individuals who have come materially short of getting their lessons. It would be a fascinating problem for the administrator to compute how long it would take a student who always gets eighty per cent to arrive at a point where he would know nothing at all, or just an infinitesimal amount. It would be a particularly entrancing curve and the latter end of this student would be at that point in the curve which approaches the line of zero achievement as an asymptote. That brings me to the second aspect of the mechanistic theory of education and to the topic which I have chosen as the head of this paper, to wit: half-learning.

The moment you attempt to calibrate in terms of percentages a measuring stick, which is to be applied to progress through the schools, you have to fix a zero point. In practice, our zero point is always the point below which we refuse to pass the student. Above that point you have to allow for a series of steps from lowest to highest at equal intervals. Twist and turn as you may, use letters instead of figures, or designations such as "good," "bad," and "indifferent," you still have the same kind of an instrument. You get involved in a piece of psychology which carries you along according to its own laws. Having accepted the premise, you have to think in terms of what the premise implies and you do so think. And the school comes to commit itself to the theory that an individual may partly know a subject, partly understand a principle, partly be able to do a thing. It gets utterly tangled up in its distinctions between mastery and part mastery. There can in reason be no stages between knowing a thing and not knowing it, between understanding a principle and not understanding it, between being

able to read English, or French, or German, and not being able to read. It is of course true that individuals may differ in the quality of their understanding or of their power. They may differ in the extent of their power or of their understanding. But the trouble with our measuring stick of achievement is that it inevitably leads us to recognize and to award credit for principles which are not understood, for knowledge which is not acquired, for power which is not gained, but which are only on the way to being understood, or acquired, or gained. And so the great mass of our students at high school and college level, below the status of lesson-getters, are inevitably half-learners. I don't believe, as a general thing, that they are even so much as half-learners.

So you see the whole percentage conception of learning is not only meaningless in itself but it leads the teacher into a most pernicious outlook upon his educational opportunity.

With lesson-learning and half-learning, intellectual interests and enthusiasms have had no chance to get a foothold. One doesn't become interested in what he only partly knows; and the intellectual spoil which the learners carry away from the course is pretty apt to be limited to "thank God that is another one done." Now, don't misunderstand me about the lesson-earner. I have a good deal of respect for him, because he is pretty apt to be a fellow with a keen sense of duty, and that is always respectable. It isn't so much that I am sorry for what he is as that I am sorry for his failure to be what he might be.

What is the "way out?" It certainly doesn't lie in the line of soft pedagogics. In a praiseworthy search for means of stimulating intellectual interests many a school has fallen back upon the device of pap-feeding. There is no evidence of success. Nor need success be expected. In the long run, the intellectual life is a strenuous life. Its appeal is an appeal to those who are capable of a strenuous life.

Nor does the way, in my judgment, lie in the direction of pedagogical alibis. We are not going to get anywhere by finding some kind of an intelligence test which will eliminate two-thirds of our load. I am sorry when I see a teacher trying to prove that a large proportion of his class is too stupid to learn. There is more hope for the class than for him. It is undoubtedly true that individuals get into high school and into college who would better not be there but you and I as classroom teachers are emphatically not the persons to say so. There is altogether too

much danger that we shall be influenced by our own shortcomings as teachers. I have seen more than one course in which I thought it was a mark of high intelligence in the student that he failed to pass it. When you stop to think of it, you haven't a shred of reason for thinking that more than a very small minority of people are incapable of intellectual interests. Their early history may have resulted in making the arousing of such interests highly improbable but that is a very different thing from asserting that they are natively incapable of such interests. You biologists, at least, know that the human race would never have gotten anywhere at all if it had not been for two characteristic instincts, which in popular language we term curiosity and conscience, the survival value of which has been critical Upon the one has hung the whole possibility of intelligent outlook upon the world, and interpretation of the environment. Upon the other has hung the whole possibility of the evolution of society. It is biologically improbable, to say the least, that any considerable part of the human race is born without this fundamental instinct of curiosity upon which the whole intellectual life may be founded—both higher and lower.

Furthermore, I don't believe that you and I, even in the maturity of our wisdom, are capable of limiting the proper scope of intellectual interests. I do know valuable people who would at once define intellectual interests to be scholarship within the narrow limits of their own post-graduate pursuits.

The way out for mathematics and science is not the way out, in my judgment, for the languages. Each department in the main finds its own way out. Bear with me, while I briefly suggest some of the marks along the way for Science and Mathematics.

In the first place, instead of thinking of the course as a series of lessons to be assigned and learned, think of it as a series of units to be taught and studied, assimilated and reacted to. The student who wanders through a course in a series of daily lessons may or may not catch its great illuminating, stimulating ideas. If he catches them, he does it only casually. Let us take our course in Chemistry, or Physics, or Geometry, and organize it as a body of ten, fifteen, perhaps eighteen or twenty big carrying units, which tell the story, and get across as a body of thinking material.

Then let us take each of these units and teach the unit briefly, succinctly, and clearly until all the pupils catch the main idea. Test to see if they have got it and then teach again until they have got it incontestably.

Then, instead of going on at once to the next, let us take days, and weeks, if needed, to broaden that unit by a great variety of reading, and experience-getting, and writing, so that each pupil shall be brought not merely to see the unit in an all-illuminating glimpse but as a thing with which he gets thoroughly acquainted. Half the trouble with our slow-moving and stolid, and inarticulate, student body is that it has been through long years of intellectual starvation, nourished only on the scrappy fragments of the typical school room text, forever without an intellectual square meal. Except in rare cases the student never gets introduced to the real meaning of intellectual life. He is pretty apt to think that his Physics textbook, or his Chemistry textbook, is Physics or Chemistry.

Finish each unit with substantial papers written in the class-room, without notes, and not mere examinations. Having given the student a clear view, and having led him to nourish himself with an abundance of intellectual food, there is reason to expect that he may be able to produce something which is himself and not merely a picture of what has been in the teacher's mind. And so, given a chance, he really has something to say, and writes a paper, for the first time in his life, perhaps, because he has something to say.

Judge your own classes, and your teachers' success, if you are an administrator of schools, by the actual interest generated as shown by unsupervised activities. When we see in the library an increasing interest in the chemical journals, we can state with a good deal of assurance what people are really beginning to take hold of Chemistry, and to generate what we want. The people who are turning out high marks do not interest me a great deal, if they are exhibiting nothing else but high marks. As one of my university colleagues remarked to his boy who was boasting about his 90, "I don't care about your 90; what do you know?"

Take pattern from the sales manager rather than from the production manager.

Is it possible to develop real intellectual interest in every pupil in every subject? I don't believe that it is, but I don't know that it is not. At all events, that is not a helpful question to raise. If we keep always before our minds the thought of the impossible we shall find that our category of the impossible soon comes to include all the possible. Rather would the question better be, "Why are A and M and W as yet failing to exhibit

any real interest in this course and what can I do to put them in the way of the coming of interest"?

Thank Heaven for the fast worker but let him demonstrate his "giftedness" by doing really independent work and a lot of it, in the form of enterprises rewarded by excess credit standing, which means something. Credit merely for being bright comes to nothing but priggishness unless "brightness" has justified itself by hard work and production. Your bright pupil who merely gets his lessons well and quickly and graduates early usually develops into that most distressing of mankind, the intellectual "Smart Aleck." Later he becomes, as a wise old professor remarked in characterizing some of his youthful colleagues, "a youthful loafer who will presently lapse into middle-aged mediocrity." In the end he is pretty apt to join the ranks of the intellectual decadents, or, in plain words, to become an intellectual grouch.

Experience with our laboratory at Chicago convinces me that much of this independent work done at high school level is of a very genuine character as actual production, though not necessarily original production. Many of the excess credit papers will compare favorably with the general run of term papers submitted at graduate level. The evidence, taken in connection with a great deal of corroborative evidence, is most suggestive of the principle that the 'teen-age youth of the day is capable of much more solid undertakings than he has been allowed to do, and that his intellectual and social development, when compared with his mental and physical development, have been seriously retarded in consequence.

The chief real obstacle which you will meet will be the widespread determination of students to look upon study as a thing which they do in return for a quid pro quo in the form of credit, not as an opportunity to develop the richness of their own characters. You will find boys and girls, young men and young women, who will ridicule the idea of doing twice as much quantity work as their mates for but little more credit on the books or in terms of promotions. That is not their fault. It is the fault of the administrative technique which has said to them and to their fathers and mothers, "Education is a thing of lessons and hours and courses and years; it is a thing of time spent and of work done, not of an inward life acquired." But youth is plastic and enthusiastic. It is not difficult for a determined administration and faculty to bring about an entire change of attitude in the whole student body.

It is a real opportunity for me to be able to make this appeal to a body of teachers of science and mathematics. You, together with the history people and the literature people, hold the firing line of education Most of the other departments deal largely with the tools of education. In your keeping are most of the highways to the intellectual life, to the real liberal education.

ELECTRIC BATTERIES REVERSE VOLTAGE AT LOW TEMPERATURES.

When storage batteries or dry cells are cooled down to 170 degrees below zero Centigrade, the temperature of liquid air, these producers of electricity may reverse their voltage. This is the scientifically startling phenomenon that has been discovered at the Bureau of Standards, Department of Commerce, by two physicists, G. W. Vinal and F. W. Altrup, who were making tests to determine the reliability of batteries at artic temperatures. So far as is known, this is the first time this phenomenon has been observed.

A storage cell of the same material as used on thousands of automobiles every day was gradually cooled down and the open circuit voltages at the various temperatures were determined. Down to 80 degrees below, the voltage remained at the normal value just as it does in ordinary operation at normal air temperature. But between 80 and 100 degrees below, after the electrolyte had "under-cooled," it increased in temperature slightly as freezing began. The voltage dropped down to nothing at about minus-100 degrees Centigrade and then, at a slightly lower temperature, strangely registered a minus reading. Still more unxpected was the fact that there were registered as high as 10 volts in the direction opposite to the normal voltage. Then the voltage violently fluctuated ranging from positive ten volts to negative ten volts. These reversals happened whenever the frozen electrolyte of the cell "ticked."

A dry cell of an electric flashlight of commercial grade was given the same cooling treatment, and after giving slightly higher voltages than normal at 115 degrees below, it gradually reduced voltage until at 170 degrees below it reversed its voltage also.

But while the voltages shown under the sub-arctic temperatures are reversed and remarably large, no hope is held out that storage batteries can be recharged by the simple method of cooling them to the low temperatures used in the Bureau of Standards' tests. The currents at these low temperatures are vanishing small, and practically they hardly exist, the tests showed. Just now the battery charging stations need fear no low-temperature competition.

The low temperature tests were begun to determine whether dry batteries would give reliable voltages at temperatures that would be encountered by the McMillian arctic expedition which recently started northward. The scientists of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington who were cooeperating in this expedition also whished to know whether dry cells were fit for use after being frozen.

Dry cells of both the ordinary type and the silver chloride cells which were also tested at low temperatures appeared to be perfectly normal after being thawed out. The small-sized storage cell used also came through the cold without damage and even the glass test tube that contained it was unbroken. This phase of the tests is likely to prove of considerable commercial importance as dry cells that are used in cold regions and accidentally frozen can be relied upon, according to the results of the tests.

IS GENERAL SCIENCE DESTINED TO GO DOWN INTO THE JUNIOR HIGH SCHOOL? IF SO, WHAT WILL BE THE CONTENT OF THE COURSE?[1]

By John C. Hessler,

Knox College, Galesburg, Ill.

When one has the task of answering a double question, like the one just read, by a double-horned prophecy, he feels very much like answering the first question in the negative, and thereby avoiding the necessity of answering the second at all. To answer the questions named, in a manner at all adequate, would require an extended consideration of the meaning of the Junior High School and an equally elaborate discussion of the meaning of General Science. The first part of the question means, presumably, this: "If the High School organization and curricula are divided into those of the Junior High School and those of the Senior High School, will General Science be found in the Junior High School? If by the Junior High School we mean the usual seventh, eighth, and ninth years, the answer to the question is undoubtedly: "Yes." I feel quite certain of this answer in spite of the fervid attempts made a few years ago to swing educational public opinon over to a two-year General Science program for the four-year High School. In my judgment this movement has not succeeded, and will not succeed, unless by a two-year program in General Science we mean to include a year of General Science and a year of Biology, each being run half time for two years as a split course. The fact remains that for the three-year Senior High School a year each of some Biological Subject, of Chemistry, and of Physics are the rule, and will continue to be the rule. The War placed an unusual stress upon the Physical Sciences, especially Chemistry; this stress, if there were no other causes, will usually reserve the last two High-School years for these sciences, during many decades to come. As a rule, the first year's work of the four-year High School will be some Introductory Science of a general, rather than of a specific character, and the second year's work will be some form of Biology, pure or applied. In the country districts the Biology work will be essentially agricultural in character.

Now as to the content of the General Science course, whether the course be given in the last year of the Junior High School or in the first year of the four-year High School. If one were to believe all he hears, in these strenuous days of controversy, he would conclude that the important thing about General

[1]Read before the General Science Sections of the C. A. S. and M. T. at St. Louis, Nov. 25, 1921.

Science at the present time is not its content, not what it may accomplish for the pupil and the community, but the method by which it is to be taught. This is only a part, of course, of the age-long contest as to whether it is better to have something to teach, or to have a method of teaching. Of this dilemma I desire to take neither horn. Everyone knows that some teachers are helped by being compelled to follow some set method of work; it is equally true that many teachers are wrecked, as vital forces in the school and community, by too much methodology. One must choose sometimes, and the choice will depend upon a number of considerations, but chiefly upon the character and aptitudes of the teacher. What is important is, first, that the pupil shall be interested in Science, that he shall ask questions concerning the world about him, including the community of which he is a part. A second result, of equal importance with the first, is that the pupil shall be in a better position, after studying General Science, to answer his own questions, or, at any rate, to know, in a small way, to what source he can go for the answer. Some teachers can accomplish this result by one method, some by another. The tragedy of General Science, as it is for all Science, is that in too many cases the subject must be taught by teachers who are not really interested in Science at all, or no more interested than in any other subject of the curriculum. For these no method is of much value.

The object of General Science instruction is, as has been stated, the interesting of the pupil in his world and its phenomena. It is desirable for the pupil to have this interest in order that he may realize how dependent he is upon natural law, and how much the knowledge of the laws of nature will benefit him in his life work and as a member of the community. This interest should carry him into some of the special sciences. It is the fashion in some General Science quarters to decry the relation of General Science to the later, special sciences. Let the course be sufficient unto itself, is the demand. To a certain extent it is true, of course, that the topics in General Science need not be selected as if the course were merely a preparation for the work of some subsequent year. But in a larger sense the course *is* a preparation, and should be held accountable for having accomplished something more or less tangible. It is far from the idea of those who pioneered in Introductory Science to ask nothing from the course but a study in methods. If the pupil leaves the educational system at the close of the ninth

year, he should have the rudiments, at least, of the great, general, scientific ideas. This is what General Science will mean to him. If the pupil continues his work into the later years of the High School, or into the Senior High School, the course should have shown him the importance of Science, and should predispose him to the election of Biology, Physics, or Chemistry, to say nothing of some of the other sciences, such as Physiography, Geology, or Zoology. In a large sense General Science *is* a preparation, and cannot be treated as though it were sufficient unto itself.

What is true of General Science in the four-year High School is true, *mutatis mutandis*, in the Junior High School, if the educational system provides this latest subdivision of High School organization. The organization of Junior High Schools, no matter what transcendent reasons may be found for them at this day, was primarily an economic one. Instead of building a new High School whenever the growing High School population burst out of its too-small quarters, it was the habit for many years to rent old houses or apartments in the neighborhood and there to house the greater part, if not the whole, of the first-year High School class. This policy, like all temporary expedients, finally reached its limit here and there, and the public decided to tax itself for a new building. But what sort of a building? In our large centers of population, with the great increase of family means, and the constant effort on the part of the school authorities to stimulate attendance by the introduction of Commercial, Home Economics, Industrial and similar courses, the race between school population and school rooms has been an unending one, with the result never in doubt. The new building was built for the overflow, which was the first-year class; then, as the upper grades were also crowded, some of the seventh and eighth grade pupils were sent over to the Junior, or Intermediate, High School building. When this synthesis of the seventh, eighth, and ninth years had been accomplished in a few places, schoolmen saw the opportunity presented, and the question of a unified curriculum for these grades became one of living interest. The end is not yet. As newer reasons for the formation of Junior High Schools, we have the following:

(1) They are a device for holding pupils in the school system during years of great student mortality, and of carrying these students over into the Senior High School, or, at any rate, of keeping them in school for one additional year.

(2) In the Junior High School provision can be made for instruction hitherto very difficult, or nearly impossible, in the grade schools. Included in this type of instruction is laboratory work in Science, Household Science, and the Manual Arts. The laboratory facilities provided need not be as elaborate as if they were in the four-year High School, with its more formal science courses.

(3) The teachers of the Junior High School may be upon a lower salary scale than if they were in the four-year High School. This follows from the fact that teachers of essentially seventh and eighth grade training may be employed instead of the college graduate now demanded by the best High Schools. This question came to College Entrance Committees in an acute form, some years ago, when they were confronted with algebra courses which were presented for college entrance, and which had to be considered as a preparation for College Algebra, but had been taken in the eighth grade of the grammar school, along with the three R's.

(4) As a fourth reason for the Junior High School we have the argument that in such an organization the special-subject teacher can ultimately be employed in the place of the room teacher. This argument has already been stated in another form.

Without going farther into the history of the Junior High School or similar types of organization, let us consider what the General Science course should be. The question assigned me includes this; but from a prophecy of the future I insist that I must be excused. I will content myself with a place among fallible mortals, and state only what I think the Science course *should* be. Part of what the course in General Science should be has emerged from the discussion that has already been presented.

(1) The course should have an experimental basis. This is true whether the instruction is by the Project Method, so called, or by the usual Deducto-Inductive method.

(2) The course should require study, reading and recitation, with some small residue left at the end of the semester or year as an increment of the student's knowledge.

(3) The course in General Science should lead the student to inquire regarding phenomena and the common practices of his community and to make a beginning, at least, of distinguishing causes from their effects.

(4) The student should be sufficiently interested in Science

to desire to study some of the special sciences of the later years.

First, as to the experimental basis of Introductory Science. The best way, in my opinion, is to have the pupil carry on experimental work for himself. This work need not be as ambitious, by a great deal, as the laboratory courses of the Senior High School, but they should encourage the pupil to see that real experimention is not a matter of flasks and beakers and condensers of a special shape and label, but a question put to nature, either for the sake of just knowing what nature's answer will be, or for the sake of deciding a difference of opinion. One of the sad things about laboratory work, whether in Junior High School, Senior High School, or College, is the small space left for the gratification of that natural curiosity which is the primitive endowment of man, and which has borne him onward in his struggle for a worthwhile civilization. Our ideal seems to be embodied in some lines of Tennyson's, although we have twisted them in a manner which I am sure Tennyson never intended:

"Theirs not to reason why;
Theirs but to do."———

and be marked upon the doing.

While advocating individual experimentation in the school laboratory, if possible, I am well aware that this is impossible, and perhaps even undesirable, in some cases. Under such circumstances, certain types of home experimentation are possible, especially if the pupil who has carried out an experiment in a significant manner at home, brings the apparatus to the classroom and performs the experiment there. The student should by all means be encouraged to try out his ideas with apparatus, if this is feasible, and if he can do so without danger. If he cannot do this at home, or in a set laboratory, he can often carry it out in class as a part of some demonstration by the teacher. Right here I wish to protest against long-range demonstrations or lectures. The fact is that the words of wisdom emanating from a lecturer's or demonstrator's desk, in circles far above the Junior High School, in point of the age of the pupil, do not get very far from the aforesaid desk. This is especially true of a demonstration with clear glass apparatus. All details of such apparatus may be blurred to the pupil at the back of the room, and that which the pupil sees may be totally different from that which he is supposed to see. If demonstrations must take the place of individual experimentation, in Junior High School

courses in General Science, the class should by all means be small, and the demonstration sufficiently informal, so that the pupils can come near the lecture table to see what is going on, and to get a bit, at least, of the "feel" of the apparatus.

As has already been said, the methods of instruction may vary, but the purpose of the General Science course must be substantially the same, whether the course is given in the Junior High School or in the four-year High School. The understanding of the world about him is what the pupil needs. In his life experience the pupil will get more of the "practical" and "commercial" than he will of the cultural, which is, after all has been said, the *fundamental*. Therefore, the science courses should give him some basic knowledge of those phenomena and laws which, for special purposes, we call physical, chemical, and biological. These are the only sure foundations for a sane study of the future, whether of practical subjects or of further cultural studies. This is true likewise for the growing knowledge which will come even to those whose means or condition render further schooling of the formal sort impossible. Science study is a sane preparation for a sane State.

THE SCIENTIFIC CURRICULA IN HIGH SCHOOLS AND THE TEACHING OF DISEASE PREVENTION.[1]

By Clarence W. East, M. D.

Department of Health, Springfield, Ill.

The scientific curricula in high schools vary within fairly definite limits. Sangamon County, Illinois is taken as a representative county, presenting urban, small town and country conditions. It has one city of 60,000 inhabitants and numerous towns of from less than 100 to 2,000 population. It presents an industrial, an agricultural and a mining community, each on a large scale.

Its high schools are those of a capitol city and a number of township high schools. We may assume that its high school curricula are representative.

The sciences taught are physics, chemistry, general sciences, meaning botany and zoology, and household sciences. By the latter is comprehended the selection and cooking of food stuffs and the selection and construction of simple garments for women and children. For the sake of being comprehensive we may add to this list physical culture and athletics.

[1]Read before the Biology Sections of the C. A. S. & M. T. Soldan High School, St. Louis, Nov. 25, 1921.

The subject further analyzed may be presented as follows:

I. What is taught of disease prevention directly.
II. What is taught by implication.
III. What additions should be made to the curricula.

I. What is taught of disease prevention directly.

Examination of text books reveals nothing at all. Questioning of teachers reveals that an occasional teacher may point out a few implications of morbid bacteriology in the biology course. Observation and acquaintance with a large number of high school pupils reveals nothing at all. The writer has three children, two of whom have graduated from high school and one of whom is now a first year student.

One of them taught four and one-half years in high school and one of them now teaches the sciences in a high school.

These all are like the Hebrew children in the fiery furnace, not a smell of fire (as far as disease prevention is concerned) having passed upon their garments.

Is this negative view borne out in household science and in physical culture?

Household sciences are taught uniformly from the viewpoint of economics. Household sciences mean household economics as far as high school curricula are concerned.

Physical culture yields nothing directly. It is uniformly taught from the viewpoint of aesthetics to the many, and from the viewpoint of athletics to the few.

To this negative view must be added the fact that a large number of pupils do not take the scientific courses, and a few in most schools must be excused from even the courses in physical culture.

II. What is taught of disease prevention by implification in the scientific curricula of high schools?

This depends upon two factors, the individual bent of science teachers and physical directors, and the deducing habits of high school pupils.

In physics, the vocational outlook is almost exclusively taught. Engineering and electricity are generally before the pupils' minds who take this course, with the exception of the few who are preparing for medicine and pedagogy. Sanitary science is rarely suggested by the high school physics course, and rarely deduced by the pupil. Chemistry is in the same class with physics. A few will teach, a few will study medicine and sanitary science. The majority who take chemistry seriously are thinking of commercial chemistry.

Physical culture yields some results in disease prevention incidentally. It intermits the physical attitudes and mental concentration of study. It may assist muscular development, though it takes for granted nutritional balance and absence of physical defects. Its contribution to disease prevention is meagre.

Athletics is in the hands of the coach who must produce winning teams. Athletics not infrequently produces the cardiac and the neurasthenic patient.

An occasional pupil may infer the fact that morbid bacteriology is a part of botany, but this inference is by no means common. Even in agricultural courses, the parallelism between parasitism in plants on the one hand and animals, including humans on the other, is rarely inferred.

As addendum civics may be dragged in, which is invariably taught as political economy not including the health of the body politic. Even a visit to the city water works by the civics class lays no emphasis upon the potable qualities which the plant is supposed to secure, but rather upon its cost per unit to the householder and its production of revenue to the city.

III. What additions should be made to the curricula?

This writer declines to say. He is not a pedagogue. He has no special knowledge of curricula and their formation. He is here by invitation and freely acknowledges all of his limitations.

The facts herein presented may speak for themselves. The following suggestions are added.

1. Public Health now approaches the whole school system as an intruder, often welcome, sometimes unwelcome, through the school physician in the majority of the cities of the first-class, and in the minority of lesser cities.

2. The public school nurse touches a great many schools, but only occasionally the high schools. She functions by sufferance except in case of actual epidemic.

3. The disagreeable phases of public health, such as quarantine and vaccination against small pox are all that usually reaches any portion of the public school population. They share this not exclusively but with all other members of the community.

4. Communicable Disease produce over 50 per cent of human morbidity. They are preventable in proportion to general intelligence and honest administration of sanitary laws.

5. Hygiene and public health are not sectarian subjects, neither are they preserves of specialists. They are fundamental

to race betterment, to citizenship, to efficiency and to a broad culture.

6. The inclusion of courses in hygiene and public health in teacher training is suggested as the method of greatest immediate value in the teaching of disease prevention in high schools.

The present science teachers in high schools are high school pupils one or more years removed as far as training in sciences is concerned. If there has been any broadening in their science training in a generation it is toward vocational and economic ends, and little if any toward public health.

THE USE OF MOTION PICTURES IN PHYSICS TEACHING.[1]

By Harvey B. Lemon.

University of Chicago, Chicago, Ill.

Of the various methods at present most effective in physics teaching, the most important are probably in the following order:

Laboratory work
Classroom recitation and problem solving
Demonstration lectures.

In the University of Chicago, for many years the demonstraton lecture was not utilized to any large extent. The reasons for this were several. In the first place, demonstration lectures require, if they are to be effective, a large amount of time in preparation. Experiments, which occupy perhaps an hour to show, may require three or four hours to set up beforehand. In the second place, it is not always possible to correlate demonstration material with classroom work and laboratory exercises that are going on at the same time; and much of value in them is therefore lost by not immediately being applied. On the other hand, it is generally felt that in subjects like physics and chemistry, there are many extremely important illustrations of modern applications and of rather striking character which can be brought into the course only through the medium of the demonstration lecture. Also, men of great distinction in special fields of work can be brought before elementary classes on one or two occasions during the year with lectures of this type. With these men, elementary students naturally have no contact in routine laboratory or classroom work. For these two reasons then, the demonstration lecture has been revived in physics teaching at Chicago with no small amount of success, and one

[1]Read before the General Section of the C. A. S. and M. T. at the Soldan High School, St. Louis, Nov. 25, 1921.

demonstration lecture hour a week, included in the program of all junior college classes. The organization of this material, sufficient in amount to run through the year, has been a very large undertaking, occupying a very great proportion of the time or two men on the staff. At least two assistants are needed solely to attend to routine of assembling and tuning up the experiments that are shown in each class.

It has long been the belief of the writer that the demonstration lecture might readily be supplanted by the motion picture, were suitable films, properly edited, available; and last year, through the cooperation of the Society for Visual Education, this experiment was tried. A group of films entitled "Famous Experiments in Electricity and Magnetism" were set up, photographed, illustrated with animated drawings, and then were tested out, briefly as follows:

Six sections of twenty-five students each were brought together on two occasions, half the group meeting in one room and the other half in another room. One group was shown 1,000 feet of film on the subject "Electrostatics." The other group was shown a demonstration lecture covering the same material. The two groups were then interchanged and those who had previously seen the film were given a demonstration lecture on Magnetism, whereas the others were shown 1,000 feet of film on this subject. The entire group was then given a comprehensive examination. Papers were marked by four different individuals, and the results averaged. It appeared that those who had seen the material presented by the lecturer in person attained a grade of 72%. Those who had seen the film averaged only 67%. In looking at these figures the following additional facts must be borne in mind. The spoken lecture was allowed an hour for presentation. The film was entirely unsupported by any comment and occupied the normal projection time for 1,000 feet, which is twenty minutes. We therefore feel quite certain that if the motion picture film is placed in the hands of competent informed teachers, preceded by some comment and followed by questions and discussion, the numerical grades above might have appeared in inverted order.

As a result of these tests, the motion picture film for the present is established in our laboratory as one of the recognized means of undergraduate instruction. It must be remembered, however, in respect to our opening remarks, that films are to be regarded as a substitute only for this one type of science instruction. It is inconceivable that they can ever take the place of laboratory or classroom work.

AIMS OF GEOGRAPHY TEACHING.[1]

By James H. Smith,

Austin High School, Chicago, Ill.

The Demand for Geographical Knowledge.

A widely circulated full page advertisement[2] of Webster's New International Dictionary mentions only two classes of words, namely, "30,000 Geographical Subjects," "12,000 Biographical Entries."

No other classes are named. The keen advertiser evidently thinks that the users of the dictionary will look for geographical terms far oftener than for those of any other class. The number given for Geography is seven and one-half per cent of the total 400,000 words and phrases in that dictionary. This reference book is used by the general public including all classes from the most scholarly to the humblest seeker after knowledge.

The business world is making a persistent demand for em-employees having at least a usable amount of geographical knowledge. Says one writer[3], "A certain amount of geography would appear to be almost a *sine qua non* for the intelligent understanding of the world of business and industry." Teachers of English and of the Social Sciences have come to depend upon a geographical foundation and setting for much of their work. In an article[4] not at all complimentary to geographers Dr. Daniel C. Knowlton, a teacher of History and Civics, reaches this significant conclusion: "The emphasis in our schools upon the social bases of all development drives the teacher of history and economics back again and again into the field of geography. Some one must lay these foundations and lay them well."

Notwithstanding these and many other demands for geography we find a general reluctance among curriculum makers to include courses in geography. This leads President James F. Chamberlain[5] to remark that, "The large omission of geography from our secondary schools is one of the weakest spots in our educational scheme."[5]

Objectives of Secondary Education.

During the last five years various educational organizations have been searching, by means of committee work, for the fundamental objectives of secondary education. Results so far

[1]Read before the Geography Section of the C. A. S. & M. T. at the Sodan High School, St. Louis, Nov. 25, 1921.
[2]Back cover, The Independent (N. Y.), Oct. 22, 1921.
[3]Knowlton, Journal of Geography, Sept. 1921, page 228.
[4]Knowlton, Geography and the Social Sciences, Journal of Geography, Sept. 1921, page 229.

[5]Journal of Geography, Oct. 1921, page 276.

as published seem to be in a fair degree of accordance with each other. That of R. L. Sandwick[6] may be regarded as typical. In his report he finds four leading "objectives," viz.: Health (physical and mental); Wealth (mental and physical); Association (unselfish and righteous); Beauty (noble enjoyment). These together contribute to the threefold life of the individual resulting in 1st, a happy and efficient worker, or Economic Life; 2nd, a happy and efficient citizen, or Political Life; and 3rd, a happy and efficient member of society, or Social Life.

To anyone versed in geography, I am sure it is evident that this subject contributes much to the Economic, Political, and Social life of the individual. Therefore a logical inference is that geography is an important subject in the curriculum.

Aims of Geography Teaching.

At a meeting of this Association in 1919 W. F. Headley and the writer in a committee report gave four chief aims of geography teaching as follows:

1. Acquisition of a fund of information pertaining to the peoples and countries of the world.
2. Understanding, appreciation, and control of the environment of the pupil.
3. Training in ability, such as problem seeing and problem solving.
4. Getting a background for the interpretation of English, History, Current Events, and, we may now add, Civics.

These are worthy aims, to meet which would call forth the best efforts of any teacher. In my judgment they stand today pointing the direction in which our efforts should go. An expansion and elaboration of these aims may help to a fuller understanding of them.

Let us consider the first object, namely, Acquisition of a fund of information pertaining to the peoples and countries of the world. This includes our own country and applies to it with especial emphasis.

Those who occupy positions of authority in state or nation need such knowledge. Without it Congress and State Legislatures would be unable to enact suitable legislation. Many extravagant appropriations for Rivers and Harbors and for Post-Offices might have been saved by more definite knowledge of the regions on the part of all the legislators. A comprehensive and intelligent plan for national and state highway building cannot be made without a thorough knowledge of geographical conditions. Illustrations might be multiplied almost without limit.

[6]Report of R. L. Sandwick, Chairman Committee on Objectives, High School Conference, University of Illinois, 1920.

Patriotism is fostered by a knowledge of geographical facts and conditions, especially those referring to the manner of life of people in different sections. In the colonial period, statesmen were afraid of the disruption of our large country because knowledge of all parts of the domain was not intimate nor commonly possessed. But with rapid communication, rapid transportation, and wide-spread knowledge among the people we now have little to fear. Our national hymn is teeming with geographical allusions. "From every *mountain side*, let freedom ring."

"I love thy rocks and rills,
Thy woods and templed hills."
"Let rocks their silence break," etc.

The thought of the poet reverted time and again to the realm of nature. A man's loyalty to and fervor for the "rocks and rills" of his country are likely to be enhanced by some knowledge of their location and character.

Second, Understanding, appreciation, and control of the environment of the pupil. New York City and its development furnish an example. Its water supply extended farther and farther from the dense population until it tapped the mountain streams at their source, and tunnelled the Hudson River in order to reach the congested city. Its transportation first used the ferry as a crossing to mainland; then the famous bridges; and later tunnels for railroad trains. Now it is to build a tunnel for automobile traffic. Thus a great city by combining deductions from geographical conditions with superb engineering skill maintains its development and growth.

Third, Training in ability, such as problem seeing and problem solving. The recognition of soil depletion by erosion and the retardation of the same by various well-known methods illustrates this aim of teaching geography. This is closely related to the second aim, and in many cases the two may be identical.

Fourth, Getting a background for the interpretation of English, History, Current Events, and Civics. As a background for the interpretation of History, we turn to a quotation from the pen of one who has been most apt in showing the relation of the two sciences. Says Miss Semple[7] "Geography, to reach accurate conclusions, must compare the operation of its factors in different historical periods and at different stages of cultural development. It therefore regards history in no small part as a

[7]Semple, Ellen C. Semple Influences of Geographic Environment, pages 10, 11.

succession of geographical factors embodied in events. Back of Massachusetts' passionate abolition movement, it sees the granite soil and boulder-strewn fields of New England; back of the South's long fight for the maintenance of slavery, it sees the rich plantations of tidewater Virginia and the teeming fertility of the Mississippi bottom lands. . . . What is to-day a fact of geography becomes tomorrow a factor of history. The two sciences cannot be held apart without doing violence to both, without dismembering what is a natural, vital whole."

For assistance in the achievement of these aims I am pleased to find a rapidly increasing body of literature—journals, magazine articles, and especially a few new text-books. With these aids, and with a public mind ever more and more ready for the teaching of this fundamental subject, we may look forward to its steady growth in our secondary schools.

TESTING LABORATORY RESOURCEFULNESS.[1]

By H. A. Webb,

Department of Chemistry, George Peabody College for Teachers, Nashville, Tenn

Expanding the Standard Test.

"The man who invented standard tests 'started something!' " Applied first to spelling and mathematics, in which actual accomplishment was easily measured in numerical terms; soon extended to subjects such as reading, writing, grammar, etc., where ideals may be simply expressed, and standards readily set; now they try to measure achievements in complicated fields of broad and diversified content, with aims and methods by no means unanimously agreed upon.

The sciences are objects of several recent tests, some merely measuring the ability to work problems[2], others the range of general information concerning science[3], and a new type[4] which calls for specific information like the customary examination, but requires "more thought and less writing[5]."

[1]Delivered before the Chemistry Section, Central Association, at Soldan High School, St Louis, Nov. 25, 1921.

[2]Franklin T. Jones, Cleveland, Ohio. Union Science Tests in Physics; in Chemistry.

[3]Downing, E. R., Univ. of Chicago. A Range of Information Test in Science. School Science and Mathematics XIX, No. 3, 228-233, March, 1919. Revised, *ibid* XX, No. 1, 77-83, January, 1920.

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Complete list up to February, 1921; Bibliography of Tests for Use in Schools, 278 titles. World Book Co., Yonkers, N. Y. 10c.

[4]Powers, S. R., Univ. of Minnesota. The Achievements of High School and Freshman College Students in Chemistry. School Science and Mathematics XXI, No. 4, 366-377, April, 1921.

[5]Glenn, E. R., Teachers College, Columbia Univ. Conventional Examinations in Physics and Chemistry vs. the New Type of Tests. School Science and Mathematics XXI, No. 7, 666-670, October, 1921; and XXI, No. 8, 746-756, November, 1921.

Table I.

Tests in Resourcefulness.

Ranked in order of difficulty, as shown by results.

1. (Set-up) A large bucket of water, fastened down; Bottle, rubber tubing. (Directions) "Fill the bottle with water from the bucket, without moving the bottle."

2. (Set-up) Burner with short connection; Plenty of glass and rubber tubing at hand; Paraffin pan and stand two feet away, fastened in position. (Directions) "Light the burner and melt the paraffin."

3. (Set-up) Bottle, pan, tubing, gas-cock and water faucet near by. (Directions) "Fill the bottle with illuminating gas, unmixed with air."

4. (Set-up) Two bottles clamped one above the other on a stand; Glass and rubber tubing, and stoppers, at hand. (Directions) "Fill the upper bottle with water from the lower."

(Note: There were numerous failures, even with these four simplest problems.)

5. (Set-up) Two bottles of odd shape; Scales, sand, and water at hand; No weights. (Directions) "Which of these bottles holds the most?"

6. (Set-up) Two sealed bottles, of equal size and weight, one filled with water, the other with oil; Scales, sand, no weights. (Directions) "Which liquid is oil, and which is water? Prove it."

7. (Set-up) Scales, sand, and 10-gram weight. (Directions) "Weigh 5 grams of sand, using the 10-gram weight."

8. (Set-up) Two rocks, one flat, one thick; Large graduated cylinders near by, and water available. (Directions) "Which of these rocks is the larger? Prove it."

9. (Set-up) Two unequal bottles, one filled with water; sand, scales, no weights. (Directions) "Pour exactly half of the water into the empty bottle."

10. (Set-up) A flask, filled with water, neck pulled out to a tiny opening. Water will not shake out. (Directions) "Empty water out of the flask."

11. (Set-up) Flask similar to above, but empty. (Directions) "Fill this flask with water."

12. (Set-up) Three unequal bottles, one filled with water; sand, scales, no weights. (Directions) "Divide the water into thirds."

13. (Set-up) Porcelain dish; tripod, burner, ring stand, clamps; large flask filled with water. (Directions) "Arrange this equipment so that the water may be evaporated in the porcelain dish while you are absent for an hour."

Table II.

Responses to the Tests.

Type of student.	Median time of response, in minutes, for test No.												
	1	2	3	4	5	6	7	8	9	10	11	12	13
	min	min	min	min	min	min	min	min	min	min	min	min	min
College men	1	1	1	2	2	1	2	5	2	5	5	3	4
College women	1	2	3	4	3	4	3	5	5	4	5	F	F
High school boys	1	1	1	1	1	2	2	3	5	3	3	F	F
High school girls	1	1	2	3	5	4	F	5	F	F	F	F	F

Condensed responses.

	Median time for all problems	% responses in 1 minute or less	% failures
College men	2 minutes	37.0%	21.2%
College women	4 "	11.0%	36.4%
High school boys	2 "	41.0%	25.0%
High school girls	5 "	19.5%	42.0%
All college students	3 "	18.4%	32.1%
All High school students	3 "	32.0%	32.5%

Which sex excells?

(a) In responses for individual problems. The minutes given indicate

how much more quickly the problems were solved; the figures represent the number of problems in which each sex excelled.

	four min.	three min.	two min.	one min.	equal	one min.	
College men		3	3	3	3	1	College women
High school boys	2	2	3	2	4		High school girls

(b) When best half of responses are considered;

74.8% college men did as well as 50 % college women.

72.5% high school boys did as well as 50% high school girls.

70.0% all males did as well as 50% all females.

Best 50% responses of college students include: 69.0% of the men, 42.5% of the women.

Best 50% responses of high school students include: 59.1% of the boys, 37.6% of the girls.

Best 50% responses of all students include: 62.4% males, 40.5% females.

Which school excells?

(a) In responses for individual problems. The minutes indicate how much more quickly the problems were solved; the figures tell the number of problems in which each school excelled.

	three min.	two min.	one min.	equal	one min.	two min.	
College men	1	2	1	3	3	3	High school boys
College women	1	2	2	5	3		High school girls
All college students		1	2	7	1	2	All H. S. students.

(b) When best half of responses are considered;

58.0% college men did as well as 50% high school boys.

59.1% college women did as well as 50% high school girls.

50.0% all college students did as well as 50.1% high school students.

Best 50% responses of males include: 53.7% of the college men, 48.4% of the high school boys.

Best 50% responses of females include: 53.0% of the college women, 45.5% of the high school girls.

Best 50% responses of all students include: 50.0% of the college students, 50.1% of the high school students.

An Unmeasured Ability.

The achievement expected of students should certainly bear a close relation to the ideals and aims of the subjects. In biology, chemistry, physics, and other sciences based upon them, at least one object is the acquirement of a certain type of ingenuity—training in a form of self-reliance which we may call *laboratory resourcefulness*. None of the tests published to date have in any way measured this valuable product of a laboratory course in science.

Resourcefulness is no doubt a composite of many mental and physical powers. General acuteness of mind is inherited; habits of observation are largely acquired; ability to reason out a logical course of procedure is gained no doubt from both heredity and training. These qualities, combined with the type of will which promptly decides and acts, make up resourcefulness.

Whether in connection with laboratory operations the male or female sex possesses the more resourcefulness; whether it increases with maturity in the absence of any special training;

these are some of the questions which only a test will answer. And if there are any fundamental underlying causes of the lack of resourcefulness as observed in so many individuals, the discovery of these causes could give a stimulating definiteness to our methods of laboratory instruction.

The problem is in the whole industrial field, as well as in the schoolroom. Robert J. Peters, director of the Pennsylvania Bureau of Employment, has recently said:

"Any man who will spend a week in this office in these days of general unemployment and will keep his ears and eyes open will close the experience with the conviction that resourcefulness is the most undeveloped trait in the workers of this country to-day." "Individual unpreparedness," he calls it.

One Thing that Hinders.

At least one cause of the lack of resourcefulness is timidity. It is the same sort of feeling a modest young lady has in the presence of a man to whom she has not been introduced; she does not know anything about this strange creature, and does not feel at liberty to try to find out anything. An electrician employed by the local Light and Power Company furnishes an excellent illustration of this same timidity applied to material things. Most of his time is spent in replacing blown fuses in the residences of patrons. "I can't see why any woman who could pull a drawer open and screw the lid of a fruit jar off and on could not jerk a knife switch and screw in a fuse. But mighty few of them will do it," he complains.

To test this phenomenon, I placed twenty young women in front of the panel of an electric light switchboard containing four or five circuits, with one fuse burnt out. The lights which would not burn were visible from the switchboard. Practically all refused to touch it; "afraid of it," "might shock me," etc., were the reasons given. A few words of explanation, a simple demonstration with the familiar tester (light bulb in socket, attached to short cord with bare ends), all without showing the fuse—barely more than the conventional "Ladies, let me introduce you to my friend Mr. Switchboard, whom you will find a gentleman of parts," etc,—enabled most of them to find and remedy the trouble.

Kipling tells the story of how tame elephants may be tied to their posts with a few straws around one foot. This repression of resourcefulness in the presence of unfamiliar things is a similar bond—the victim does not realize how easily freedom may be obtained.

Testing Laboratory Resourcefulness.

The tests on laboratory resourcefulness—soon to be described—were first offered to students who had absolutely no experience in a laboratory. They simply refused to touch the apparatus. The delicacy of thin glassware, the intricate appearance of trip-scales, the strange feel of black rubber tubing; these seemed to create a feeling of awe. Expressions such as "Will this glass break?" "Will I hurt these scales?" etc., show the nature of the mental obstacle. No progress whatever could be made in the tests.

A homely illustration makes this point even more clear. Suppose we wished to measure the ingenuity of city-bred men in harnessing a mule. Every city man has been taught that mules kick and bite. Fear of the probable consequences would make it impossible for the men to demonstrate their real ability to decide how the harness should be arranged. With a gentle mare as a subject, the test could be carried out.

These tests in laboratory resourcefulness were then given to one group of 43 high school students, and another of 34 college students, both classes having had just enough experience in the laboratory to eliminate the temporary influence of strange apparatus. Each student worked individually, and could not see what others were doing. The actual manipulations of any test could be performed in less than one minute after the student decided just what to do. A maximum of five minutes pondering and trial were allowed, then failure was recorded. Some limit had to be set; with such simple problems, success after ten minutes of wasted effort would mean little more than if an hour had been used. The tests given are outlined in Table I.; the responses, here treated in a very simple statistical manner, in Table II.

Responses to the Tests.

In many ways, only a few of which will be detailed in this discussion, the responses to these tests are typical of those of any test. Accepting a representative, average group of students, no problem is so easy that some will not miss it, none so difficult, if within reason, that some will not solve it. The simplest problem, No. 1, has six failures marked against it; the most troublesome, No. 13, has four one-minute responses. Median performances, of course, are the most instructive data, and in this limited report, are the only values discussed.

It cannot be argued that the ranking of these thirteen prob-

lems represented intrinsic difficulty *per se*, for they were all actually very simple. Most phenomena are miracles, until somebody explains them; most accomplishments impossible, until somebody does them; most tasks which confront us difficult, until we try them, and find how easy they really are. Even the least resourceful student, having seen all the experiments performed, could hardly say which was the hardest and which the easiest. The variable and measurable thing is the time of response to the problems as new, but many times seventy seven students would of necessity be tested before any standard response, as to time, could be agreed upon for these, or other problems. The method, which is the principal thing offered here, will bear scrutiny, it is hoped, and possibly extension.

Which sex excells in resourcefulness? The evidence of this test gives honors to the male, confirming a truth which common observation has already probably sufficiently established. Have the psychologists an explanation for feminine lack of resourcefulness in contrast with the masculine average? Do they know why there are so few women inventors? And why, with the undeniable possession of greater manual dexterity, more patience, more rapid adaptability in learning new manipulations, does she, the average woman, defer to her average brother in originality?

Which school excells in resourcefulness? There is only a shade of difference; somewhat in favor of the high school, where one-minute responses are considered; slightly to the advantage of the college when the sexes in each group—men and boys, women and girls—are compared. Maturity does not develop resourcefulness spontaneously; men and women do not acquire ingenuity by the mere circumstance of growing older. Neither may it be deduced from these figures that the bold assurance of adolescense is resourcefulness, else the dashing youngsters would have surpassed the more deliberate adult.

This equality in resourcefulness is in harmony with other observations on the ability of adolescents. An illustration is the extreme youth of many amateur wireless operators, who show originality and enthusiasm equal to that of many adult professionals. Such things give the high school teacher much pleasant confidence—what project in construction is too difficult for his boys and girls, if it is really worth while? Marvellous things which they have made under the pressure of their own interest and a teachers' enthusiasm are convincing witnesses.

Training in Resourcefulness.

At least one of the objects of an elementary course in any science should be to give that familiarity with apparatus, reagents, and technique which will remove all hinderance to natural resourcefulness. Thus is built a foundation of experience which will support the new problems—give the self-confidence which comes with successful experimenting—supply a method of attack which will serve for the forward push. If he will, any teacher of a laboartory subject can constantly place before his pupils tasks which will train their resourcefulness. His projects may readily be graded, first setting simple manipulations, like those which comprise the tests described in this article, then proceding to more complex problems. To the extent that it may be predetermined, these may correspond to the future needs of the student, being typical of the emergencies he may meet in the industrial laboratory, the prospector's open field, or (as in the case of students in my institution) the high school and normal school laboratories equipped for biology, chemistry, physics.

A Poor Type of Training.

An illustration of how *not* to train resourcefulness may be illuminating. As one of a large group of students of physiological chemistry in a university laboratory, I profited by the daily use of Barfoed's, Benedict's, Biol's, Bottu's,———Zenker's reagents, following directions on mimeographed sheets. As far as we knew, the bottles containing these reagents had grown upon the shelves where we found them, there was never one more, and never one less of them. Although depleted of their contents during the afternoon, in the morning these bottles had filled themselves by the same miraculous power, we believed, which resided in the milk pitcher of Philemon and Baucis, or pervaded the kitchen of the widow of Zerephath, whose barrel of meal wasted not, and whose cruse of oil did not fail. There was, it is true, a small room where much powdering, washing, and stirring went on, into which we could peep through a tiny sliding door, but we were never allowed inside its sacred precincts. Is it any wonder that reagents, costly both in money and time spent in their preparation, were poured out freely as water, and that we threw excess materials with gay abandon into the sink.

Our mimeographed sheets frequently referred to "special"

solutions, which we always found labeled "Special Solution for So-and-so." There was considerable special apparatus—glass blown to special order, and of particular dimensions.

What results might be expected? A new instructor in Home Economics in an important institution in the northern states sent down a requisition to the chemical laboratory for some Fehlings No. 1. A short time afterward she sent back the blue crystals which had been furnished her, with a note to the effect that she had supposed the chemist would know what Fehlings No. 1 was, but if she must be more specific, it was a *blue liquid* which she wanted. Her training had been in one of the largest laboratories of the country.

Another Poor Method.

Recently we have read much of a plan adopted for the elementary chemistry classes in one of the important institutions of our land. The student, on opening for the first time the desk assigned him, finds every chemical reagent he will use during the course, not only prepared, but even weighed out in the required quantity. I wonder what such a student would do later if elected to a high school position where he must put twenty pupils at a desk for ten, arrange shelves, bottles, prepare solutions from reagents which he has never seen before in original packages, make out an order for materials, and stay within a lean budget! I have talked with such students, who, after a year or more of laboratory work, had never seen the original package form of KOH, sodium, phosphorus, "arsenous oxide solution," and bromine water. I have seen one throw away a large bottle full of lead acetate solution *because it was cloudy*, and make up some "fresh." I have seen one give up in despair, because the sodium nitrate solution was "out." I have seen one order "sodium chloride, commercial" from a chemical supply house five hundred miles away, instead of patronizing the grocery nearby. The price list of the supply house has the item, too, for the benefit of innocent purchasers—"Sodium chloride, com'l, per pound, 10 cents, bottle, 8 cents extra."

It is bad enough for a student to think that reagents grow on a shelf, but worse to have the impression that they grow in the desk drawer, having come spontaneously, without effort or information on his part. Will such experience teach him resourcefulness in operating a laboratory of his own? Does carrying in bottles of milk each morning train a city man to coax the lacteals of a country Bossie? Will taking breakfast in bed teach

the debutant, sub-, this-season, or ex-, the art of collaborating with a stove in preparation of a meal?

Students, while under instruction in any form of scientific laboratory, cannot learn too much about the details of its operation. A way can always be found to let them assist in preparing reagents, distributing equipment, learning the tricks of the business that are never found in the books.

The Training that Endures.

At the close of a course in any laboratory science, every teacher knows that by a majority of the class the formulas, classifications, and mathematical details will soon be forgotten; properties of substances, descriptive matter, and general principles will be retained in proportion to how frequently the knowledge is used; but that a trained and developed resourcefulness has been planted upon a certain amount of native ability, given a key which is familiarity with the tools and methods of the work, and stimulated by the remembrance of difficulties solved in the past by ingenuity. This art of resourcefulness, like the knack of being able to swim, will endure through all life.

BELGIAN SCHOOL SUGGESTS EXCHANGE OF STUDENTS AND TEACHERS.

A rather unusual opportunity is presented through the Belgian Ambassador to the United States and the Belgian Director General of Agriculture and Horticulture, who suggest that it might be of mutual advantage to the United States and Belgium if a number of American young women might attend the Normal Institute of Agricultural Home Economics in Laeken. It is also suggested that American agricultural colleges might "exchange" students or teachers for a time with the Belgian Institute on a "living expense" basis.

The purpose of the school is to prepare young women for all phases of rural life. About half of the students' time is devoted to formal instruction and half to practical work. If one wished to enter the institution, negotiations could be opened through the Belgian Embassy in Washington. Under the present exchange rate it would be relatively inexpensive for American girls to take advantage of this opportunity.

An experiment station is maintained in connection with the Institute where agricultural implements and products may be tested.

The school is in one of the suburbs of Brussels, in grounds that until recently formed part of the royal domain of Hosseghem and have been donated for their present purpose by the royal family. The Queen of the Belgians has been personally interested in the development of the school. Its director, Dr. Jean Lindemans, spent some time in the Office of Home Economics, United States Department of Agriculture and visited many agricultural colleges and home economics schools in the United States while the plans for the Laeken Institute were being developed.

ELEMENTARY SCIENCE AS A PREPARATION FOR CITIZENSHIP.[1]

By G. W. Hunter,

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In the days when Roman and Grecian civilization held sway over the then uncivilized world, these nations owed their prominence to the training of their citizens. Since that day, except during the times when the light of civilization was so nearly blotted out before the days of the Renaissance, training for citizenship has only been stressed in a limited group. But today, in a democracy in a country where neither wealth nor brains nor color nor race is supposed to either delimit or limit a man from the qualifications of citizenship, such training as will make for leadership in a democracy should be sought in all schools supported by public money.

But what, then, is citizenship? What qualities do we most admire in the citizen of today? First of all, we feel that he must be law-abiding; that he must have respect for laws binding on the greatest as well as the lowest; he should respect the rights of others; he should be able to see their point of view and at the same time understand the rights and wrongs of the men entering in competition with him; that he should have information of the sort which will be of most value in living a straight, upright and helpful life of service and that he should be able to use this information; that he should be unwilling to accept dogmatic statements on the simple "say-so" of others and should demand as a basis a fact, which is established; that he should, above all, be able to think and think straight. This last great feature is most essential because the political life of today is swayed by unscrupulous leaders who use half-truths and *untruths* to convince unthinking and prejudiced minds. When we witness the hundreds of thousands of voters, who, because of lack of the qualifications along the lines just stated, sway our state and national politics, and when we realize that these people vote at the word of unscrupulous politicians and are moved by statements in even less scrupulous newspapers and periodicals, owned by these politicians, then we realize that our education for the masses is not working out for the making of thinking citizens.

But how can we evolve a training that will make for a straight thinking of the kind that will function in a democracy where

[1]Read before the General Science Section of the C. A. S. and M. T. at Soldan High School, St. Louis, Nov. 26, 1921.

votes are paid for and where numbers count? It seems to me that, primarily, respect for law can best be taught by knowledge of the law and order in Nature—that order in the physical, chemical and biological world which the student of elementary science must come in contact with in a well-balanced course. It is through the laboratory work in such a course—through the project, if you will—that students come to realize the value of individual research and the need of respecting the rights of others. It is through directed information of this kind that the future citizen may get information which will counteract, to an extent, at least, the influence of untruths and half-truths which are so often published in the daily newspaper. But most of all, it is through science in the secondary school that a child may be directed into the lines of real thinking. No other one thing is so much needed at the present time as the ability to think straight. Those of us who have read Dewey's "How We Think" realize that he as a master, recognized that through the vehicle of the experiment we may teach the fundamental basis of the thought process. Someone has said that "an experiment is but a form of asking a question of nature." Nothing could be truer. And it is experimental work in the laboratory or outside of it in the form of a project through which a child of today gets his best training, that carries over into his daily life as a basis of the sylogistic form of the thought process.

It has become quite the thing for the man of today to measure himself in terms of ability or resources, both mentally and physically. The score card idea has reached down into our daily life from the business world, just as the mental test is beginning to reach into it from the university. A case in point might be the work of the Life Extension Institute. This institution, although advisedly a money-making project, has for its basis an excellent psychology, as have most successful business projects of today. The wise man is one who sooner or later checks up on his own strong and weak points, physically. He must learn where the organism is weakest, for it is the weak link in the chain that snaps the chain. By means of such an examination as the Life Extension Institute suggests, this chain of life may be extended simply through rightly directed knowledge of the make-up of the organism. The question then arises: should not the citizen of today be willing to put his own community to a similar test? Should we not be more willing as citizens to pay attention to the strong and weak points in our own community? For

example, should we not train our children, as future members of their own community, to know something about local conditions with reference to geographical location, the amount of sunlight it gets during the year, the physical constituents of the soil; the purity and sufficiency of its water, milk and food supply, its transportation facilities, the municipal cost and distribution of such public utilities as water, gas and electricity, and the one hundred and one details of a physical, chemical and biological nature that constantly should come, but which *do not* come under the jurisdiction of the average citizen of today.

How many of us, I wonder, could score our own community with reference to the work of the health department, of its hospitals and schools, of its recreational facilities, of the cost of water, gas and electricity, as compared with neighboring sections of the country. Too many of us are entirely satisfied and some believe that because our particular town or city has certain excellent points in its favor, that no other things are needed. Is it not true that the growth of hundreds of small cities in the Middle West are today being hampered by lack of soft water or water which can be used in boilers of manufacturing plants? Frequently a surface water supply could be impounded from the surface run-off but is not, simply through the inertia of the city leaders in public affairs. A town not far from Galesburg, Illinois, recently spent $8,000.00 on a fire engine and could not get water enough out of its mains to test the engine which had been bought! I live in a city which is mentioned by Edwin Bok as one of the three most desirable small cities in the United States in which to live. This city is well-treed, well-paved and to an extent, fairly well-governed. It has perhaps a larger proportion of college graduates than most other small places, and yet it possesses an open sewer which flows through the town, reeking with odors and containing bacteria of more than several deadly diseases. The state has pointed out the danger of the open sewer and ordered its closure, but the town is satisfied to let the malodorous stream meander through its midst untouched. Why does this happen in such a community, you ask? Is it because it does not appeal as good business? It it because there is no money return in it? Is it because the money expended will not show a monument to civic pride? Or is it, primarily, because the college and business men of the community have not in the past been educated to realize that public health is the biggest asset a town can have, and that it should be purchased even at a high price.

This would lead us to wonder whether our public schools have been educating in the past in preparation for every day citizenship. The citizens pay for the public schools—why should they not get some return on their investment that will be of value to them as law-abiding citizens? Therefore, why not make our science teach those things which will give the future citizen a foundation of knowledge of the sort that will make him a useful member of the community? Does our high school science of today do this? As a biologist, I am afraid that I must answer that to a great extent it does not do this. When we go into a class-room and see boys and girls counting the segments in the abdomen of a grasshopper; or observing the number of hooks and pads on the tarsus; I say with a good many other hard-headed citizens who supply money for our public educational facilities, "What practical value has this work in training for citizenship?" Or when I go into a physics class and observe the knotted brows and uneasy postures which denote disgust with mathematical calculations, I wonder just where physics is helping toward making better citizens. And even when I observe spectacular experiments in the chemical laboratory, which fascinate and interest the citizens of tomorrow, I am prone to ask myself just where is the application in life of that citizen of tomorrow. Are we aiming along the right lines in science of today, or more properly I should say, have we been hitting the mark?

Huxley was a scientist of yesterday, yet he defined science as classified common sense. How much common sense, I wonder, is there in the work of the average science teacher which directly influences the average citizen in the average community in this country? It is not that we have not the material with which to work, for science material lies in abundance at our doors, in our homes and around about us. The child of today is brought up in an atmosphere of practical science, and yet how many of us are explaining the problems with which he comes in contact in his daily life? There is surely as much science training in testing water for chlorides, or reading gas meters, or learning how to exterminate mosquitoes, or testing grain for germination, or doing the one thousand and one practical things that the average citizen in a small or large community needs today, as there is in working out forty experiments in physics or sixty in chemistry for the College Entrance Board examination.

Biologists of today know, all too well, now that Israel Zang-

well's "Melting Pot" is an impossible dream. They know, that intermarriage between races invariably drags the better stock down to the average of the lower and that race assimilation is biologically impossible. But the foreigner is here to stay and he must be educated in order that he at least will receive the point of view of a citizen in a democracy like ours. It is the place of the science teacher of today to realize that his place in the democracy is that of bringing this unassimilated material into at least as close harmony with the original stock of the nation as it is possible to do. Science, then, can lead us along practical lines to the goal which has been suggested by the recent report by the Committee on the Re-organization of Science. That goal is expressed briefly in the following well-known statement: Science instruction in the light of modern research in education may be made especially valuable in the realization of six objectives: namely, health, worthy home membership, vocation, citizenship, the worthy use of leisure, and ethical character-building. We, as teachers of introductory science, must constantly seek to treat our own work in the light of these objects—and we must furthermore be prepared to throw away such material as does not measure up in the testing as leading the child toward those objectives.

Let us now see if there is any practical ways in which elementary science of today may actually do some of the things that has been suggested by this committee. A few nights ago I picked up one of the two daily Galesburg newspapers and in looking through the paper, culled thirty-one patent medicine advertisements from one paper. One of these advertisements occupied considerably more than one-eighth of the sheet and read, in part, somewhat as follows: "Biggest thing of the kind ever seen here. Entire train-load of a certain patent medicine sold in Illinois and Missouri in only a few months' time." The advertisement goes on to say that the local demand for this medicine is remarkable, sales in Galesburg having reached the total of 5,224 bottles. One druggist makes the statement that "on one Saturday alone we sold more than seventy-two bottles and the sales are now averaging more than twenty-seven bottles a day. The class of people who are buying this are among the best in our city, people who are capable of judging impartially and who carry weight in their statements." The interesting thing about this medicine is that it contains in the neighborhood of thirty per cent alcohol. In other words, a city with two col-

leges and a college population of more than 1,200, containing a number of college graduates larger per capita than the average town, allows its drug stores to fill their windows with a patent medicine which is a substitute for whiskey and sell this to the intelligent (?) citizens at the cut rate of eighty-eight cents per bottle. This same advertisement had the effrontery to put in the statement by Abraham Lincoln, "You can fool some of the people some of the time, and all of the people some of the time, but you can't fool all of the people all of the time." It looks in this case as if most of the people were being fooled.

But how many older people as well as younger people are cognizant of the true working of the Pure Food and Drug Act? How many of them know that while it may prevent misrepresentation and mislabelling and while it places the names of certain poisonous drugs on the label, it is practically inoperative because of a lack of knowledge on the part of the people and because of the fact that the daily newspapers are subsidized by the patent medicine interests. How many teachers in this room, I wonder, know the entire working of the Pure Food and Drug Act with its lack of operation because of the Inter-State commerce laws. How many people know what their own state laws are in respect to the Pure Food and Drug Act. How many know whether their state provides for the safe-guarding of its citizens from adulteration and poisons? How many know that although certain poisons are by law placed on the labels of medicine, certain other poisons, even more deadly, are not required by law to be placed upon the labels? How many of us realize that a ghastly traffic in testimonials, bought with the life-blood of innocent women and sold at the rate of $5.00 a thousand by regular vendors, is going on at the present time and that these testimonials are being scattered broadcast in the smaller newspapers over the land.

How many know of the work of the American Medical Association and its anti-patent-medicine propaganda. Is your course in elementary science using this material and are you combatting these evils in an intelligent and systematic way. If so, science in your community is making that community a better and safer place in which to live. If not, then you have something yet to add to your course.

What better training for citizenship do we have than that of making future citizens willing to serve others in his community? Here is a type of work which might be done by all. A few years

ago there was instituted in the high school in which I taught a service squad—a squad of boys who became interested in making sanitary conditions around the school better—a group of boys who were willing to give up part of their lunch period every day to supervising the room—a group who made public opinion in the schools so strong that the throwing of food and paper on the floor became almost unknown—a squad that later on came to supply a certain amount of self-government in the school and which definitely patrolled not only the school but the streets in the immediate neighborhood and made that part of the city cleaner and better. This group and its practical service were the direct outcome of the elementary biology course in the school. All of you know of Professor Hodge and his splendid work, first in Worcester in the clean-up campaigns in the elementary schools, later through the agency of his anti-mosquito and anti-fly campaigns in different parts of the country. All of us who have headed up such campaigns know what it means to see young people go out into a community and through their own efforts sway public opinion into cleaning up a community. This is not so difficult, for all one has to do is to start the public sentiment through some practical application of science and your community will take care of its part. As Gruenburg, so well said in a recent article in the Atlantic Monthly:

> "The boy who learns to kill mosquitoes and to spare the lady-birds will probably not be the richer for it when he comes to make his will; but the community that learns to kill its mosquitoes and to spare its lady-birds will surely have an incalculable balance in its favor. The occasional individual who learns to avoid spitting is still exposed to infection from the spitting of others; the community that first eliminates spitting and pencil-licking will probably be the first to eliminate the white-plague. If an understanding of the relations of bacteria and ventilation and diet and work to people's health will lead a generation of citizens to oppose with all their might the building of unsanitary dwellings, the operation of ill-ventilated factories, the marketing of unwholesome food and quack remedies, and the overworking of men, women and children, such an understanding is worth all it costs. No other knowledge given to all the children of a nation will do so much for the general welfare as an appreciation of the relations between man and the organic factors of his environment."

Elementary science should also teach conservation—and conservation in its widest and truest sense. We, of this country, have been given a great heritage in our rich mineral resources, our fertile lands, our great forests, in our oil and coal and water power, and yet how few children of practical farmers know the true meaning of fertility of the soil! How few of us realize that forest destruction is hurting the farmer of today as well as the lumberman of yesterday. How few of us realize that in the

high price of commodities which we fight today, there harks back a cry to the carelessness and waste and extravagance of a generation who but a few years ago cut and hewed and devastated some of the natural resources from the face of our life!

No one of us who has gone along the Illinois River can fail to realize the need of conservation of such a resource for future generations. Fish are extinct in certain parts of the river today. You say it was fish, or human lives. True, human lives are more to be conserved than fisheries, but the pollution of the Illinois River can be measurably lessened if private individuals are made to take care of factory wastes. It is not the pollution of human wastes that causes the fish extinction, but through the wastes which should be eliminated before they reach the drainage canal. All of this and more are topics which rightfully come under the jurisdiction of the live teacher of elementary science today.

Talking of conservation, how many of us are teaching in our conservation work the fact that there is a well established lobby backed by certain moneyed interests which is at the present time endeavoring to take away from the people the conservation rights which are theirs in our national parks. It is worth our while as science teachers to keep in touch with this situation. Bills were introduced last year which planned to take certain water power from the Yellowstone Park; dam Yellowstone Lake and ruin for all time some of the unique, natural monuments in that park. This bill will undoubtedly come up again at the present session of Congress. The Executive Secretary of the National Parks Association as a watcher for ends bills in Washington, uncovered the other day a joker in a certain bill planned to establish a Roosevelt Memorial Park. This joker takes the rights of water power from the National Park Commission and puts it into the hands of a local water power commission. Our future citizen must be alert to save for his children the heritage which is ours today, and eternal vigilance is the necessary factor where politics play a part today.

Finally, the health of a community is a public obligation. Children should get, through their science work, the applications of science which lead to health and to future happiness of citizens. They should know about public money as spent in their town, how much the schools are doing for public health, how much money is spent on recreational facilities, how much of the public budget goes into the Health Department, and

whether this health work is free from political restrictions and the will of the politician. Here too is the place, through the natural agency of the flowering plant, to introduce the children to the subject of sex so that real sex education may be built up in the biology course in the high school.

Let me not be misunderstood. Let us give a course in elementary science which shall have the basic principles of science. Let us not be superficial. Let us teach scientifically. Let us make our laboratory a place for experiments and for thought projects. Let us train above all, for straight thinking, but let us remember that the nation's greatest asset is the health of its citizens and that any course in elementary science should first of all interpret the environment of the pupils so that they may best prepare themselves for a life in that environment or for the bettering of that environment, if it is humanly possible; and second, that the scientist of today should act as a leader in all school projects with applications which make for human welfare and for faithful, intelligent and law-abiding citizenship.

To teach food values to children and to combat malnutrition the American Museum of Natural History circulates a traveling exhibit which includes a set of sixteen wax models of food suitable for children between the ages of ten and thirteen and models and charts illustrating the composition of six common foods and the contributions of different foods to the body.—*School Life.*

NEW MATHEMATICAL PERIODICALS.

By G. A. Miller,

University of Illinois, Urbana, Ill.

In walking through the cemetery of mathematical periodicals one can scarcely fail to be impressed by the large infant mortality which has thus far existed in this field of endeavor. Even after the age of infancy the death rate has been very high, so that if life insurance would have existed as regards these periodicals the premiums would necessarily have been very high in order to avoid disaster to such insurance companies. Only one of these periodicals has as yet reached the good old age of a hundred years, viz., the *Journal de l' Ecole Polytechnique,* which was started in 1795. In fact, the question might be raised whether the mathematicians have a clear right to claim this journal since it does not acknowledge complete allegiance to our subject by its title or by its subject matter.

The oldest journal which acknowledges its allegiance in such a definite manner is the *Journal für die reine und angewandte Mathematik*, which was founded in 1826 by A. L. Crelle and is often called *Crelle's Journal*. While it has not yet quite reached its hundredth birthday, it has passed its one hundred and fiftieth milestone, each volume being regarded as a milestone. The one hundred and fifty odd volumes of this journal occupy an honorable position in the mathematical periodical literature and bespeak a memorable service towards the upbuilding of our subject during almost a century of undreamed of progress.

It may be noted that the dates when the two old mathematical journals just mentioned were founded are often given as a year earlier than those given above. These are the dates, or correspond most nearly to the dates, which appear in the first volumes of these periodicals, but it must be admitted that the first numbers of a periodical frequently appear in an earlier year than the complete first volume. As the bound volumes usually do not give any evidence as regards the dates when the separate numbers appeared it seems to the present writer best to date references to journals, as a rule, with respect to volumes rather than with respect to the publication of the separate numbers to which the special references may relate.

We refer to this matter here partly to emphasize the fact that the mathematician is in danger of going to extremes as regards accuracy relating to certain details. One of the most helpful elements in mathematical training is the cultivation of a keen appreciation of *reasonable* accuracy. Napoleon may have been correct in saying that Laplace, whom he had made minister of the interior, "did not seize a question from a true point of view, that he sought subtleties everywhere, having only problematic ideas, and that he carried the spirit of the infinitely little into administration."

It is difficult to define what reasonable accuracy is. In fact, most people probably have to study such accuracy by means of example, and hence we may be pardoned for a slight digression here for the purpose of furnishing two or three illustrations which we hope are not without interest for other reasons since they are related to well-known works. On page 404 of the 1919 edition of Cajoris *History of Mathematics* it is stated that "early in the development of the theory of point sets it was proposed to associate with them numbers that are analogous to those representing lengths, areas, volumes. On account of the great

arbitrariness of this procedure several different definitions of such numbers have been given. The earliest were given in 1882 by H. Hankel and A. Harnack."

On turning to page 423 of the same history one finds that H. Hankel died in 1873 and one is naturally interested in knowing why it is stated that he gave certain definitions about nine years after his death. On looking the matter up in the French encyclopedia of mathematics to which reference is given one finds that in treating the subject quoted above the writer of the article in this encyclopedia gave reference to a reprint of an article by Hankel. This reprint was published in 1882 in the *Mathematische Annalen*. The original article had, however, been published in 1870 in a somewhat obscure place. Presumably one would be inclined to say that the encyclopedia reference was reasonably accurate, even if it gave rise through carelessness to a somewhat amusing situation in the mathematical history noted above.

On the other hand, one would probably not regard a statement appearing on page 163 of this history as reasonably accurate. It is here stated that Roberval" broke off from the ancient definition of a tangent as a straight line having only one point in common with a curve." It is evident that the ancients might have thought that a tangent line at the point of tangency had only one point in common with the curve, and that they might have concluded that a necessary and sufficient condition that a straight line is tangent to a circle or to an ellipse is that it has one and only one point in common with such a curve but they must have noticed that such a condition is not sufficient to insure that a straight line is tangent to such a curve as the cissoid of Diocles, for instance.

In questions involving mathematical considerations the mathematician naturally demands a degree of clearness and accuracy, which cannot reasonably be demanded as regards many questions which are related to his work but do not involve any strictly mathematical considerations. For instance, it would appear to me as reasonably accurate to state that Jordan's *Traité des substitutions* was published in 1870 because this date is given in the book itself, and hence I would be inclined to overlook in this connection, the fact that Jordan himself stated on page 116 of volume 10, *Giornale di Matematiche*, that he published this book at the end of 1869.

Besides the two old mathematical periodicals mentioned above

there are several others which have passed their three score years and ten. Among these the *Journal de mathématiques pures et appliques*, first edited by J. Liouville, is, perhaps, most favorably known. As is well-known the World War has seriously affected a number of our journals, including some of the older ones. Several of these are now in a very critical condition and it is too early to predict whether they will be restored to health or will share the fate of the many soldiers who never returned. Fortunately, periodicals can sometimes be revived even after having passed a long time in a dormant state.

The preceding references to some of our oldest periodicals may serve to create in us a feeling of greater complacency as regards the prospects of the numerous infant mathematical periodicals now in our midst, notwithstanding our earlier reference to the great mortality among such infants in the past. May we not hope that the world has grown wiser also as regards the proper care of such infants and that a relatively large number of those now in this class may attain not only their three score years and ten but may continue to grow in power and in usefulness during all the future years. It seems only reasonable to assume that our world will never again reach a stage when it has no special mathematical periodicals.

The most rapidly growing infant mathematical journal now in our midst is the *Mathematische Zeitschrijt*, founded in 1918 under the editorship of L. Lichtenstein. According to the announcement only two volumes of this periodical were expected to appear annually but a considerably more rapid average growth has been maintained thus far. The high standard of its articles is a source of much satisfaction to all of us. While the publication of many other mathematical periodicals has recently been greatly delayed, even in our own country, it is interesting to note this rapid growth in a country where the economic conditions seem to be unusually adverse now as a result of the World War.

Several of the younger infants among the mathematical periodicals were mentioned by name in the "Notes" of a recent number of the *American Mathematical Monthly*, volume 28, pages 315 and 317. On the latter page it is stated that ten such periodicals were started since January, 1919. It is too early to say much about these infants. Perhaps it would be wise to follow in this case the example of the shrewd pastor whose common expression when addressing the mother of a young infant is said to have been, "Well, that *is* a baby."

While we give hearty welcome to these new periodicals and are especially pleased to see so many countries represented by them, it is very important to realize our responsibility towards the older ones. Many of the latter are now in need of more liberal support in view of the changed economic conditions. There is, however, plenty of room also for the new ones as most of them occupy fields which were not covered by the older periodicals. The growth of our subject and its increasing influence on other subjects need these new periodicals as well as a vigorous maintenance of those which have a long history of usefulness.

COURSES IN COMMERCIAL SUBJECTS FOR THE SUMMER QUARTER AT THE UNIVERSITY OF CHICAGO.

An unusual opportunity for teachers of commercial subjects will be offered by the University of Chicago for the summer quarter beginning June 19 and ending September 1. The School of Commerce and Administration and the School of Education announce a wide range of courses of special interest to commercial teachers in secondary schools, including "Materials for a Secondary-School Course in Business Administration." "The Teaching of Secondary-School Economics," "Methods of Teaching Shorthand and Typewriting," "Teaching of Secondary-School Accounting," and "Materials for Secondary-School Course in Marketing and Salesmanship."

Other courses include: "Materials for Junior High-School Course in Social Studies," "General Technique of Instruction in High Schools," "The Psychology of Secondary Education," "Geography of Asia: Industrial and Commercial Conditions and Possibilities," "Ocean Trade and Transportation," "Business Law," and "Government Finance."

MOUNTING PRINTS.

Although the effectiveness of a photograph can be very greatly increased if it is mounted neatly and with taste, an untidy or unsuitable mount is even worse than no mount at all, says a British contemporary. Many photographers appear to find it very difficult to get a print stuck down on card in such a way that it lies perfectly flat, and there is no sign of mountant oozing out at the edges. So long as mountants that contain water are used, the difficulty of mounting a print so that it will keep flat must inevitably exist; and it is, therefore, amazing that more photographers do not adopt the very simple plan of attaching the print by its two top corners only. Provided it is to be kept flat, in a portfolio or otherwise, a print mounted in this way looks quite as well as if it had been stuck down all over; and, at the same time, it looks very much better than most of such stuck-down prints can ever do. When the print is dry, it should be made as flat as possible by drawing it once or twice round the edge of a ruler, or similar object with a sharp right angle along it. It is a good plan to give it more treatment than is sufficient to flatten it, so as to leave it with a very decided curl, with the face convex. In this condition it may be shut up in a book or put under pressure for a few days, and will then come out flat and ready for trimming and mounting. The slightest touch on the two top corners with a suitable adhesive will be all that is necessary.—*Photo-Era.*

A COLLEGE WHICH EDUCATES FOR MOTHERHOOD.

Vassar College does not send out women to become great lawyers, doctors, scientists, business administrators, or money makers, according to Dr. Lyman Abbott. It has been doing something much better than that. It has been educating women to be great mothers. We can estimate in dollars and cents the worth of a lawyer or a financier, but it is impossible to estimate the worth of a mother.—*School Life.*

TUOLUMNE CANYON 4,000 FEET DEEP.

Tuolumne River rises in a group of glacial lakes on or near the Sierra divide in California. The river flows through beautiful upland meadows in its upper part and then through a canyon, nearly 80 miles long, which it has cut in solid granite. For a distance of about 25 miles, according to the United States Geological Survey, Department of the Interior, the upper part of this canyon is 3,000 to 4,000 feet deep and is known as the Grand Canyon of the Tuolumne. At the lower end of this canyon lies Hetch Hetchy Valley, which is smaller than the Yosemite Valley but resembles it very much in every other way. The river finally passes through its lower canyon into the San Joaquin Valley.

LANTERN SLIDES OF PARTICULAR INTEREST TO BIOLOGICAL LABORATORIES.

Teachers of biological subjects are always meeting the problem of familiarizing students with the facts of cell division, and with the phenomena of maturation and fertilization. Very excellent diagrams, covering the subject, have been published many times; but few schools have the actual material for clearly demonstrating these cytological facts. Next to observation of the actual material itself, photographs of it make the facts vivid and credible.

During the recent war, Professor O. Van der Stricht of the University of Ghent, Belgium, was in this country, and in the course of his studies made many beautiful preparations of the eggs of Nereis, the marine annelid worm. Many of these preparations he gave to the Anatomical Laboratory of Western Reserve University, and through its cooperation with the department of Zoology of Oberlin College, the following photomicrographs have been made up into lantern slides: 1. Entrance of spermatozoon. 2. First maturation spindle located centrally. 3. Ditto, located peripherally. 4. Ditto, with first polar body before detachment. 5. First polar body detached, second maturation spindle, and male pronucleus. 6. Second polar body detached, male and female pronuclei adjacent. 7. Pronuclei fusing. 8. First cleavage spindle, three polar bodies. 9. Metaphase, first cleavage. 10. Anaphase, first cleavage. 11. Telophase, first cleavage. 12. Two cell stage.

The set is offered at $15.00, carriage prepaid, and orders may be sent to Robert A. Budington, Spear Laboratory, Oberlin College, Oberlin, Ohio.

It is further explicitly mentioned that all proceeds from these sales, after defraying cost of production and delivery, go to Professor Van der Stricht to assist him in the restoration of Belgian biological science, especially in the publication of the Archives de Biologie of which he is an editor. Thus, purchasers will not only augment their own equipment, but will materially assist in a greatly deserving cause. The slides are strictly high-grade, and only very favorable comments have been made about them.

PROBLEM DEPARTMENT.

CONDUCTED BY J. A. NYBERG,
Hyde Park High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to him. Address all communications to J. A. Nyberg, 1039 E. Marquette Road, Chicago.

LATE SOLUTIONS.

716. *E. Tabor, Upper Lake, Calif.*, remarks on some of the peculiarities of the series 1, 2, 3, 5, 8, 13, 21, ...

In any set of four terms, the sum of the extremes equals twice the greater mean, and the difference of the extremes equals twice the lesser mean; also the difference of the squares of the extremes equals four times the product of the means. And the sum of n terms of the series is two less than the $(n+2)$nd term.

717. This problem was solved last month by using a mean proportional. The following solution by *J. F. Howard, San Antonio, Texas*, is quite different.

Construct the triangle, given $\angle A$, the length d of the bisector of this angle, and the sum e of the including sides AB and AC.

On the bisector lay off $AF = d$. On one side of the $\angle A$ lay off $AE = e/2$. At E draw $ED \perp AE$. On FD as a chord construct a segment of a circle with $\angle A/2$ as the inscribed angle, and let B and B′ be the intersections of the circle with AE. Join B to F and produce to meet AC at C. $\triangle ABC$ is the required $\triangle$. The use of B′ instead of B, will give a triangle congruent to ABC.

The proof is based on the fact that a circle can be circumscribed around ABDC (since $\angle DAC = \angle DBC$), BD = DC, and hence AB+AC proved equal to 2AE.

718, 719. *E. Tabor.* In 719 all 4 cases were solved.

720. *Nevada Tabor.*

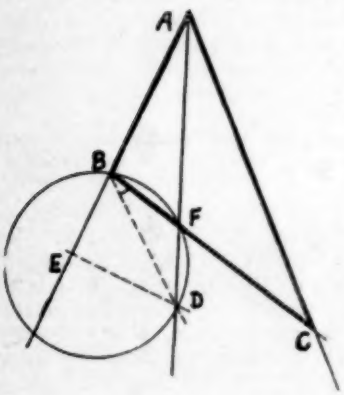
SOLUTION OF PROBLEMS.

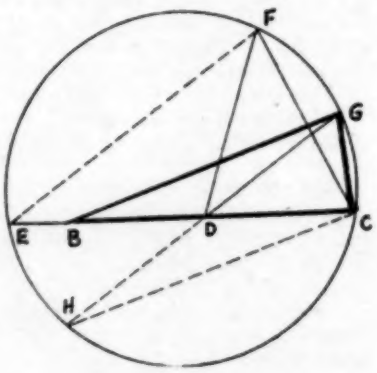
712. *Proposed by Daniel Kreth, Wellman, Iowa.*

Construct the triangle, given the base, a, the difference of the two adjacent angles, and the median to the given base.

Solution by J. F. Howard, San Antonio, Texas.

Bisect the base BC at D, and make $DE = m^2/DC$, where m is the given





median. Construct $\angle DCF = \angle K$, the given difference of the two base angles, and $DF = DE$. Describe a circle through the points C, E, F. Through D draw GH parallel to EF. Join G to B and C. $\triangle GBC$ is the required triangle.

Proof. Since GH is parallel to EF, and $DE = DF$, the diameter bisecting EF perpendicularly passes through D and is perpendicular to GH. Hence $HD = DG$ and

$$\therefore DG^2 = DC \times ED = DC \times m^2/DC = m^2 \quad \text{or} \quad DG = m.$$

Since $BD = DC$ and $HD = DG$, $\triangle BDG = \triangle HDC$ and $\angle GBC = \angle BCH$. But $\angle BCH = \angle FCG$ because arcs EH and FG are equal. Hence, $\angle GBC = \angle FCG$, and the difference of the base angles is correct.

[The readers will agree that this is a clever solution of a difficult problem. —*Editor.*]

721. *Proposed by Wm. B. Campbell, Philadelphia.*

Starting with two equal piles of material, a and b, one-third of that in a is transferred to b, then one-third of b's new total is transferred to a, etc., indefinitely. A condition is manifestly approached where each pile alternates between 4/5 and 6/5 of its original condition, but give the general expression stating the fraction in each pile after n transfers.

Solution by Michael Goldberg, Philadelphia, Pa.

The amount remaining in the pile a, after a removal of material is $2A_n/3$, where A_n is the amount before removal. The sum of the two piles is $2a$, and hence the amount after the next transfer is $(2/3)A_n + (1/3)[2a - (2/3)A_n]$. Hence the amount after the second transfer is $(2/3)a + (4/9)A_n$.

Beginning with a, the amounts after every second transfer are (using the relation above):

$A_0 = a$

$A_2 = a(4/9 + 2/3)$

$A_4 = a(16/81 + 8/27 + 2/3)$

$A_6 = a(64/729 + 32/243 + 8/27 + 2/3)$ etc.

The first term is $2a/3$ (n even). The other terms form a geometric series whose ratio is 4/9. Summing the series, we get:

$A_n = a(2/3)^n + (6a/5)[1 - (4/9)^{n/2}]$; $B_n = a(2/3)^n + (4a/5)[1 - (4/9)^{n/2}]$.

In the same way when n is odd:

$A_n = a(2/3)^n + (4a/5)[1 - (4/9)^{(n-1)/2}]$;

$B_n = 2a(2/3)^n + (6a/5)[1 - (4/9)^{(n-1)/2}]$.

Also solved by *E. Tabor, Upper Lake, Calif.*, who expressed the results as

$A_n = (6 \cdot 9^n - 4^n)/(5 \cdot 9^n)$; $B_n = (4 \cdot 9^n + 4^n)/(5 \cdot 9^n)$ (n even).

$A_n = (12 \cdot 9^n - 2 \cdot 4^n)/(15 \cdot 9^n)$; $B_n = [2(9^{n+1} + 4^n)]/(15 \cdot 9^n)$ (n odd).

The editor feels that problems such as this one and the one in problem 716 are more interesting than the determination of convergence or divergence. Let's have some more.

722. *Proposed by Walter R. Warne, Pennsylvania State College, State College, Pa.*

Without using the trigonometric formula for the radius of a circumscribed circle, prove that in the ambiguous case of the triangle (wherein two sides and an angle opposite one of them are given), the two circumscribed circles of the two triangles are equal.

I. *Solution by E. Tabor, Upper Lake, Calif.*

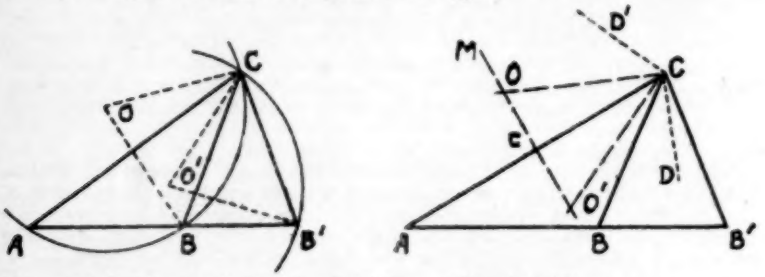
If O and O′ are the centers of the circles circumscribing $\triangle ABC$ and $\triangle AB'C$ respectively, then $\angle COB = \angle CO'B'$ because each equals $2\angle A$. Hence the arcs BC and BC′ are equal; and since their chords are also equal, the circles are equal.

Similarly proved by *Edward Lewis, Junior Class, Redlands H. S., Calif., Nelson L. Roray, Metuchen, N. J.*, and by *Harry Sohon, New York*, who adds that by this proof we see that any two triangles, having an angle of each equal and the sides opposite these angles equal, will have their circumscribed circles equal.

II. *Solution by T. E. N. Eaton, Redlands High School, Calif.*

To draw a segment upon AC which will contain $\angle B'$ (or its equal $\angle B'BC$) we draw the perpendicular bisector ME of AC, and lay off on

each side of AC the angles ACD′ and ACD equal to ∠B′. At C draw ⊥s to CD and CD′. The ⊥ to CD intersects ME at O which will then be the center of the circle through A, B, C. The ⊥ to CD′ intersects ME at O′, the center of the circle through A, B′, C. Then △OEC = △O′EC being right triangles with EC common and the angles at C each complementary to ∠B′. Hence the radii of the circles are equal.



III. *Solution by R. V. Pritchard, Missouri School of Mines.*

Let a, b, c and a, b, c' be the sides of the two triangles and r and r' the radii of their respective circumscribed circles. Then $\triangle ABC/\triangle AB'C = cb/c'b = c/c'$ since the triangles have a common angle. Also $\triangle ABC = abc/4r$ and $\triangle AB'C = abc'/4r'$ according to the formula for the areas. Hence $\triangle ABC/\triangle AB'C = r'c/rc'$. The equality of this ratio with the previous one gives $r'c/rc' = c/c'$, whence $r = r'$.

IV. *Solution by Irma Luelleman, Mattoon, Ills.*

In any triangle the product of two sides equals the product of the diameter of the circumscribed circle by the altitude upon the third side. If the triangles are ABC and AB′C and h is the altitude from C to the line AB′ then in $\triangle ABC$ we have $ab = 2rh$; and in $\triangle AB'C$, $ab = 2r'h$. Hence $r = r'$.

V. *Solution by J. F. Howard, San Antonio, Texas.*

If ABC and AB′C are the two triangles, then ∠ABC is the supplement of ∠AB′C. Rotate △ABC about the line AC as an axis calling the new position AB_1C. Then $\angle AB_1C$ is the supplement of ∠B′ and a circle may be circumscribed about the quadrilateral $AB'CB_1$, and this circle is the same as the circle through ACB_1 and equal to the circle through the congruent △ACB.

Also solved by *Michael Goldberg*, and by *A. Pelletier* in four ways (I, IV, and in V either of the two triangles may be rotated about the line AC).

723. *From an examination paper sent in by John Lundberg, Goteborg, Sweden.*

The logarithm of a number to the base 10 equals the sum of its logarithms to two other bases, of which one base is one-tenth of the other base. What are the two bases?

I. *Solution by R. T. McGregor, Elk Grove, Calif.*

If x denotes one base and $x/10$ the other base, and n any positive number, then from the conditions of the problem

$\log_{10}n = \log_x n + \log_{x/10}n$; but $\log_x n = \log_{10}n/\log_{10}x$

Hence

$\log_{10}n = \log_{10}n/\log_{10}x + \log_{10}n/\log_{10}(x/n)$.

or $1 = 1/(\log_{10}x) + 1/(\log_{10}x - 1)$

or $(\log_{10}x)^2 - 3\log_{10}x + 1 = 0$; $\log_{10}x = 2.6180$ or $.3820$.

The bases are approximately 415 and 41.5, or 2.41 and .241.

Also solved by *Norman Anning, Ann Arbor, Mich.; T. E. N. Eaton; Michael Goldberg; J. F. Howard; A. Pelletier; R. V. Pritchard;* and *Nelson L. Roray.*

II. *Solution by E. Tabor, Upper Lake, Calif.*

By the conditions of the problem $10^{n+m} = a^n + (10a)^m$. As the ratio of the bases are constant, the ratio of n to m is constant, and we may choose $m = 1$. Then

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$$10^{n+1} = a^n = 10a$$

From $10^{n+1} = 10a$ we get $10^n = a$ and if we substitute this value of a in $10^{n+1} = a^n$ we get $10^{n+1} = 10^{n^2}$. Hence $n^2 = n+1$; $n = (1 \pm \sqrt{5})/2$, and then a can be found.

Several solvers pointed out the curiosity:

$$10(41.5) = 415;\ 10(.241) = 2.41;\ (.241)(41.5) = 10$$

724. Restated as problem 726.

725. *For high school students. Proposed by the Editor.*

It appears that on a certain day last week Mrs. A started out to call on Mrs. B, and when she reached the domicile of the latter learned that Mrs. B had been gone just eleven minutes on her way to Mrs. A; and so Mrs. A at once returned to her home. Mrs. B had reached the mansion of Mrs. A fifteen minutes after the latter had left; and so she retraced her steps toward her own home. On their return trips the ladies met at a point just midway between their homes. How many minutes does it take each of them to walk from one house to the other?

Solution by Harlan Beem, Mattoon H. S., Ills.

Let x = time it takes Mrs. A to go from one house to the other.

Let y = time it takes Mrs. B to go from one house to the other.

If when Mrs. A arrives at the home of Mrs. B she finds that Mrs. B has been gone 11 minutes, and since it takes Mrs. A $x/2$ minutes to walk half of the distance back, then $11+x/2$ is the number of minutes needed by Mrs. B to walk from one house to the other and half way back. Therefore

$$3y/2 = 11+x/2$$

Similarly,

$$3x/2 = 15+y/2$$

The solution is $x = 14$, $y = 12$. It takes Mrs. A 14 minutes to walk the distance and Mrs. B 12 minutes.

Also solved by *Beatrice Batterson*, and *Edward Lewis of Redlands, Calif.; Edward A. Ravenscroft, New Trier Township H. S., Kenilworth, Ill.; Nevada Tabor, Upper Lake, Union H. S., Calif.*

In a problem of this type the chief difficulty is in deriving the equations, and the next difficulty is to explain them in such a way that a reader can easily follow the explanation. The two equations above are alike in various ways: the left members are both 3/2 times a variable; the right members are both a constant plus 1/2 times the other variable. Only one of the equations needs explaining because the other is so much like it. If just one unknown, x, is used all this symmetry is lost.

PROBLEMS FOR SOLUTION.

736. *Proposed by J. T. Crawford, University of Toronto, Canada.*

A geometric and a harmonic progression have the same pth, qth, and rth terms, a, b, and c, respectively. Prove

$$a(b-c)\log a + b(c-a)\log b + c(a-b)\log c = 0.$$

737. *Proposed by Henry L. Wood, Boonton, New Jersey.*

Without using parallel lines, construct the fourth proportion to three given lines, a, b, c.

738. *Proposed by J. F. Howard, San Antonio, Texas.*

A and B are points on a diameter and equidistant from the center. CBD is any chord through B. P is any point on the circumference. PA intersects CD in E. Can the point P be selected so that PBE will be an isosceles triangle?

739. *Proposed by Ethel E. Barneby, Twin Falls, Idaho.*

ABCD is a square barn, 40 feet on a side. A cow is tied at A with a rope 100 ft. long. Over how much ground can the cow graze?

[The editor is frequently asked for the area when the barn is rectangular, in dimensions a by b, and the rope c feet long.]

740. *For high school students. Proposed by N. L. Roray, Metuchen, N. J.*

Give as many proofs as you can of the theorem: An angle formed by a tangent and a chord drawn through the point of contact is one-half the central angle of the chord. State which proofs are original and which from a text book.

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AN INTERNATIONAL STAMP BOOK—A PROJECT IN GEOGRAPHY FOR THE INTERMEDIATE GRADES.

By Douglas C. Ridgley

Illinois State Normal University, Normal, Ill.

That phase of geography commonly known as the study of the world as a whole is usually treated in fourth grade or fifth grade. The year's work is usually so extensive that teacher and pupils may profit by some class project to run like a game throughout the year with which much of the year's work may be associated. A project that may be easily introduced, and which may be participated in by all pupils, may be named "An International Stamp Book."

The following suggestions will serve to direct teacher and pupils in the development of this project. Other methods of work will be found as the collection grows. The teacher should always keep in mind the geographic value of the project and develop it as a means of making the daily work in geography more definite and concrete.

1. Make a list of forty or more countries of the world for the teacher's reference. The name of a country need not be given to the pupils until a stamp is offered from the country for the collection.

2. Ask pupils to bring for the school collection postage stamps from th United States and from any other country. Include in the school collection only one stamp of the same denomination and design, but encourage efforts to obtain as wide a variation as possible in both denomination and design.

3. When a new stamp is offered for the collection, give each pupil an opportunity to examine it and to decide whether or not it is new to the collection. If new, it is to be added in the school collection, otherwise it may remain the property of the owner for his personal collection or for exchange.

4. Provide means of mounting the stamps in a permanent stamp collection book. This may be an ordinary loose-leaf notebook to which pages may be readily added and in which the sheets may be shifted from time to time to accommodate the growing collection.

5. Place emphasis on cancelled stamps, those that have seen actual use for transportation of letters or packages. Uncancelled stamps, new stamps of interesting denomination or design may be added as opportunity affords. Cancelled and uncancelled stamps of the same denomination and design, mounted side by side, will prove interesting and instructive.

6. In mounting cancelled stamps, much interest will be added by mounting not only the stamp, but also the address and postmark. If the stamp is on a letter, the entire envelope, or a portion of it, may be pasted in the book. If the stamp is on a package, the addressed label with stamp attached may be placed in the exhibit.

7. A separate sheet in the collection book should be devoted to each country, with the name of the country printed neatly at the top of the sheet. In the loose-leaf notebook, additional sheets may be added for any country as the collection grows, and new sheets for new countries may be inserted at the proper place to preserve a geographic sequence. The collection should be arranged geographically by continents and countries rather than alphabetically.

8. When a stamp for a new country is offered, each pupil should find the country on the globe, and trace, on the globe, the journey of the stamp from its place of issue to the school. The direction and approximate distance of its travels should be determined. This exercise offers exceptional opportunity for the study of the globe far superior to any *formal*

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exercise devised for globe study, and each child should participate in the exercise.

9. After a globe idea of the journey has been well established, the same journey may be traced on a wall map of the world and related to the globe. These exercises offer opportunity for study of the globe and the world map in relation to each other. Impress the idea that the globe is the *accurate* representation of the earth and of a journey such as the stamp has traveled; that the flat map is more commonly used than the globe, because it is more convenient to make on a large scale, and to use in books and on the wall.

10. Interest on the part of the teacher will stimulate interest and activity on the part of pupils. The personal contact of the boys and girls of a geography class with relatives and friends is so wide, that unexpected sources for foreign stamps are sure to appear. By making every stamp added to the collection a real geography lesson for each pupil, the collection serves an important part in making geography definite and concrete. The stamp collection is of real value in geography only as the geographic associations are definitely and firmly fixed.

11. The stamp collection project, carried on by pupils who are studying the world as a whole in fourth or fifth grades, will give a first-hand contact with many regions to be studied in the later years of geography. This will stimulate further study and wider reading when these countries are taken up for more detailed treatment in the higher grades and by means of the advanced textbook and supplementary readers in geography.

12. Classes in the higher grades may profit by collecting stamps from the continent under investigation. Europe and South America offer special attractions for this work.

From Magazine Service of National Council of Geography Teachers. A. E. Parkins, Director, George Peabody College for Teachers, Nashville, Tennessee.

HEAVY ANCIENT FORESTS IN NORTH DAKOTA.

Fossils have been aptly called the illustrations in the great book recording the world's history, the pages of which are the layers of rock that form the outer part of the crust of the earth. By looking at some of the photographic reproductions of fossil plants we can restore in imagination the ancient vegetation of parts of the world.

Fossil plants are very abundant in the Fort Union formation, a series of Tertiary rock beds in North Dakota, where they are found in the sandstone, in the harder concretions or lenses, and in the clay between the beds of sandstone. Most of them, especially those in the clay, are preserved with remarkable fidelity. About 300 species of plants from this formation have been described, and the total number of species it contains may perhaps reach 500 or more, according to the United States Geological Survey, Department of the Interior.

This abundant fossil flora shows that what is now an almost treeless plain was once covered with splendid forests of hardwoods, interspersed with scattered conifers and ginkgos. The presence of numerous and at many places thick beds of lignite make it clear that in this region there were great swamps, which must have existed with but little change for long periods of time. Among the plants of this epoch were fig trees and a fan palm with leaves 5 or 6 feet across, indicating that the climate was as warm or warmer than that now prevailing on the South Atlantic slope of the United States.

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Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Acknowledgments.

Examination papers have been received from:
D. G. Sequist, Benton High School, St. Joseph, Mo.
G. Hapgood Parks, Bancroft School, Worcester, Mass.
Annie Cloyd, Central High School, Oklahoma City, Oklahoma.
Thank you! Send some more.

Examination Papers.

392. *What is the matter with the examination that follows? Criticize freely. Try the examination on your classes and report results.*

The following examination paper was proposed in answer to this question:

"Can you possibly find time to set an examination—one hour—for my *college preparatory physics*—on solids, liquids and gases, with the six simple machines as covered by Black & Davis, first 118 pages?

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Examination Questions in Physics.

The following list of questions may reasonably be answered by a class that has covered the first 117 pages of Black & Davis physics. Time: One hour.

Answer 3 questions only for a *pass* grade.

Answer 5 questions only for an *honor* grade.

1. What is the mechanical advantage of a machine?

A uniform beam, of length 8 ft. and mass 12 lb., is supported horizontally by two vertical wires respectively at distances 1 ft. and 2 ft. from the ends of the beam. Find the tensions in the wires.

Find also the mass of a body such that, when it is suspended from one end of the beam, the tensions of the wires become equal.

(Melbourne, Australia, School Leaving Exam.)

2. How would you verify that the apparent loss of weight of a body when immersed in a liquid is equal to the weight of the liquid it displaces?

The volume of a solid is 120 cubic cm. What will be its apparent loss of weight when immersed in a liquid of density 1.15 grams per cc.?

(Intermediate Education Board for Ireland.)

3. Explain how the principle of work may be applied to the calculation of the mechanical advantage of machines, and find the mechanical advantage of that system of pulleys (neglecting their weight and friction) in which the same string passes around each of the pulleys.

How would you determine by experiment the efficiency of such a system?

(University of Wales, Matriculation Examination.)

4. State the law known as the "Parallelogram of Forces."

Show by the parallelogram law that if three forces acting on a particle are in equilibrium, they can be represented by the three sides, taken in order, of some triangle.

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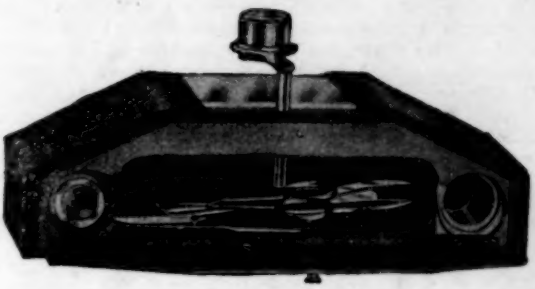

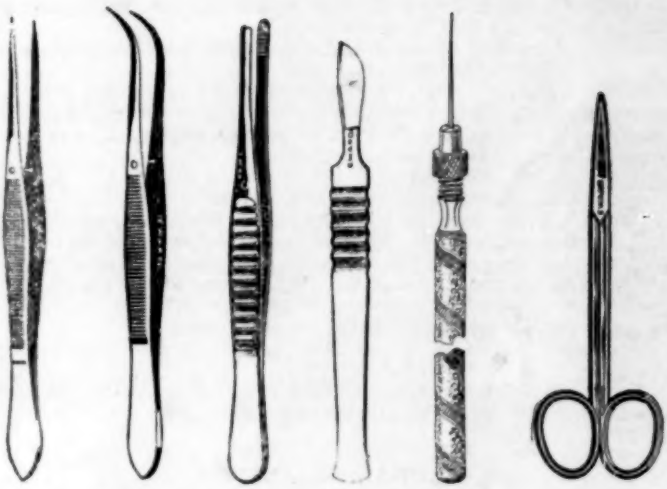

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ABC is an equilateral triangle. Three forces act simultaneously on a particle placed at B, viz: 12 poundals in the direction AB, 12 poundals in the direction BC, and 15 poundals in a direction parallel to AC.

What is the amount and direction of the resultant force?

(Scottish Universities Entrance Board, Preliminary Exam.)

5. To a glass ring of .893 gm. weight and 2.51 specific gravity is attached a strip of mineral whose weight is .528 gm. The whole is then placed in a liquid in which it sinks. By adding small portions of another heavier liquid which mixes with the first, the glass ring and mineral are made to float. The specific gravity of the liquid is then found to be 3.18. Find the specific gravity of the mineral.

(Sweden, Student Examination, High School.)

6. A pole XY, 25 ft. long and weighing 80 lb., lies horizontally on the ground. The end Y cannot slip along the ground, and the centre of gravity is 10 ft. from Y. If the end X is raised 7 ft. above the ground—

(a) what force, if applied to the best advantage at X, will be necessary to keep the pole in this position?

(b) how much work will have been done against gravity while raising it?

(Oxford, England, Local Examinations.)

7. Explain a method of determining the specific gravity of a solid which is (1) heavier, (2) lighter than water.

A piece of wood weighs 144 grammes in air and a piece of metal weighs 36 grammes in water. When fastened together the two weigh 24 grammes in water and 8 grammes in a solution of specific gravity 1.1. Find the specific gravities of the wood and the metal.

(University of London, England, Intermediate Science.)

8. Describe the Bramah (or hydraulic) press.

In a Bramah press the ram is 20 inches in diameter and the pump plunger is 2 inches in diameter. What is the velocity ratio of the machine?

What force must be applied to the pump that the pressure of the water may be 1,000 lbs. wt. per square inch? What force will be exerted by the ram?

(University of Cambridge, England, Local Exams.)

9. State what you know about the principle of the conservation of energy.

Give two examples from everyday life of the conservation of energy.

(Melbourne, Australia, School Intermediate Exams.)

SOLUTIONS AND ANSWERS.

370. *From an examination paper of Cambridge University:*

A ship A was 20 miles due north of another ship B at noon. A was sailing due south at the rate of 12 miles per hour, B due east at 9 miles per hour. At what time were they nearest each other: and how far apart were they then?

Solved by Smith Turner, Parkersburg, W. Va., and Michael Goldberg, Philadelphia, Pa.

SOLUTION BY MICHAEL GOLDBERG, PHILA., PA.

Calling the time x, and the distance y, we get the following equation:

$$(20-12x)^2+(9x)^2 = y^2$$
$$400-480x+225x^2 = y^2$$

Differentiating and equating to zero gives,

$$-480+450x = 0$$
$$x = 16/15$$
$$y = 12$$

The time will therefore be 1.04 p. m., and the distance will be 12 miles.

Extract from letter of Charles R. Herrich, High School, Everett, Mass.

The physics problems from Sweden that were printed in the January number of SCHOOL SCIENCE AND MATHEMATICS were of great interest to my class. I challenged the boys to solve any of the problems without help.

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The enclosed solution of problem 385 came in the next day. Everett MacQuarrie is a student in the senior year of the Everett, Mass., High School.

385. *Solution by Everett MacQuarrie, Everett, Mass.*

To a glass ring of .893 gms. wt. and 2.51 specific gravity is attached a piece of metal whose weight is .528 gms. The whole is then placed in a liquid in which it sinks. By adding small portions of another heavier liquid, which mixes with the first, the glass ring and metal are made to float. The specific gravity of the liquid is then found to be 3.18. Find the specific gravity of the metal.

(1) When the volume is to be found and we have given the weight and sp. grav. (which is equal numerically to the density) we can use the formula $(V = W/D) = V = W/S.\ G.$

(2.) Since the glass and metal when tied together just float, their combined volumes are equal to the volume of the displaced liquid. Also the weight of the displaced liquid is equal to the sum of the wts. of the glass and metal. Archimedes' principle explains this.

Then from (1.) the volume of the glass with wt. of .893 gm. and 2.51 sp. grav. = .893/2.51 c.c.

Letting x represent the sp. grav. of the metal with weight of .528 gm. its volume = $.528/x$ c.c.

Since the weight of the displaced liquid is equal to the sum of the wts. of the glass and the metal (2.) and has a sp. grav. of 3.18, its volume = $(.893+.528)/3.18$ c.c.

From (2.) we have learned that the combined volume of the glass and the metal are equal to the volume of the displaced liquid. Hence the following equation will result: $.893/2.51+.528/x = (.893+.528)/3.18$

$$\begin{aligned} 2.83974x+4.2143904 &= 3.56671x \\ -3.56671x+2.83974x &= -4.2143904 \\ -.72697x &= -4.2143904 \\ .72697x &= 4.2143904 \\ x &= 5.797 \end{aligned}$$

Since x was used to represent the sp. gravity of the metal the above result is what we were looking for.

5.797 or 5.8 is sp. grav. of metal. Ans.

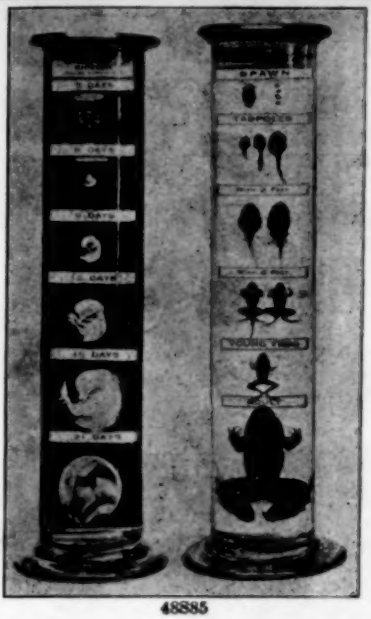
OHIO RIVER HAS ENORMOUS DISCHARGE.

In volume of water Ohio River is the main tributary of the Mississippi. Its average discharge, according to the records of the United States Geological Survey, Department of the Interior, is about 300,000 cubic feet per second, which is much more than the discharge of St. Lawrence River at Ogdensburg, N. Y., although the drainage area of the St. Lawrence is nearly twice that of the Ohio. The maximum flow of the Ohio is approximately 1,500,000 cubic feet per second, about 30 times the minimum flow.

A comparison of records of the flow of Ohio River with those of the upper Mississippi and Missouri shows that although its drainage area is but one-third that of the combined Mississippi and Missouri its average and low-water flow is 1.3 times as great as their combined flow, and its maximum flow is 1.5 times as great. This fact is accounted for by the greater rainfall in the Ohio basin and by the general character of the region.

In the Ohio basin there are apparently many opportunities for storage, especially on the southern tributaries. On topographic maps of the Geological Survey that cover part of the drainage area of the Ohio a large number of reservoir sites have been located, some of them of enormous capacity, and it is believed that careful surveys would show many sites suitable for dams that would impound large quantities of water in reservoirs.

The volume of water flowing in the Ohio may perhaps be better appreciated by noting that a discharge of 300,000 cubic feet per second would in one day cover 595,000 acres to a depth of 1 foot.



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American Mathematical Monthly, for October, *Lancaster, Pa.*, $5.00 *per year*, 60 *cents a copy*. "Religio Mathematici," D. E. Smith; "Mathematical Association of America: Election to Membership," W. D. Cairns; "The Sixth Summer Meeting of the Association," W. D. Cairns; "Mathematical Problems in the Work of the United States Coast and Geodetic Survey," W. D. Lambert and O. S. Adams; "Among My Autographs: 12. The Marquise du Chastellet; 13. Cassini Completes the Great Survey of France," D. E. Smith; "Questions and Discussions: Discussions—'A theorem on hypocycloids, by the method of circular coördinates,'" T. L. Bennett; "On the Irrationality of Certain Trigonometric Functions," R. S. Underwood; "Recent Publications: Review by Professor R. C. Archibald," "Articles in Current Periodicals;" "Undergraduate Mathematics Clubs: Club Activities—Hunter College; University of Kentucky; Syracuse University; Trinity College; University of Wisconsin;" "Problems and Solutions."

Condor, for January-February, *Eagle Rock, California*, $2.00 *per year*, 40 *cents a copy*. "The Reddish Egrets of Cameron County, Texas" (with nine photos), J. R. Pemberton; "Magpies Versus Livestock: an Unfortunate New Chapter in Avian Depredations" (with two photos), S. Stillman Berry; "Notes on the Dipper in Yellowstone National Park," M. P. Skinner; "Some Birds of Roosevelt Lake, Arizona" (with map and one photo), Hartley H. T. Jackson.

Education, for January, *120 Boylston St., Boston, Mass.*, $4.00 *per year*, 40 *cents a copy*. "The Project in Geography," Frea K. Branom.

Journal of Geography, for January, *Kenosha, Wis.*, $2.00 *per year*, 25 *cents a copy*. "A Quarter-Century in Geography," Albert Perry Brigham; "The Trend in Economic Geography," J. Paul Goode; "The Place of Physiography in Geography," Nevin M. Fennemann; "Maps in School Geographies," Mark Jefferson; "Home Geography," William Morris Davis; "Twenty-five Years' Growth in Collegiate Geography," Geo. J. Miller; "Geographical Publications."

Photo-Era, for January, *Boston, Mass.*, $2.50 *per year*, 25 *cents a copy*. "With the Patriots at Valley Forge," Philip and Leora Wallace; "Architectural Traditions for the Photographer," Edward Lee Harrison; "Winter-Sport and Photography in Switzerland," Carine and Will Cadby; "Selling Your Photographs," Frederick C. Davis; "Preparing Light-Sensitive Photographic Papers, Part I," Charles E. Mullin.

Scientific Monthly, for February, *Garrison, N. Y.*, $5.00 *per year*, 50 *cents a copy*. "Growth in Living and Non-Living Systems," Ralph S. Lillie; "Mental and Physical Effects of Fresh Air," Wm. A. McCall and Bronson L. Huestis; "Progress of Public Health Work," Dr. J. Howard Beard; "Electrons and Ether Waves," Sir William Bragg, F. R. S.; "Chemistry of the Blood One Hundred Years Ago," Dr. George R. Cowgill; "Enumeration Errors in Negro Population," Dr. Kelly Miller; "Weather Control," D. W. Hering; "Fishing in the Mississippi," A. S. Pearse; "Flower Seasons," Charles Robertson.

THE NEW PRESIDENT OF THE CHICAGO ACADEMY OF SCIENCES.

The newly elected president of the Chicago Academy of Sciences is Dr. Henry Chandler Cowles, Professor of Plant Ecology at the University of Chicago. Professor Cowles, who was also elected president of the Botanical Society of America at the recent Toronto meeting of the American Association for the Advancement of Science, has been President of the Association of American Geographers and of the Ecological Society of America. He has recently made important investigations for the government along the Red River for use in connection with a suit between the states of Oklahoma and Texas in the Supreme Court of the United States.

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310 East Bridge Street, Streator, Illinois,

BOOKS RECEIVED.

Measuring Minds, by Caroline E. Meyers and Garry C. Meyers, Cleveland School of Education. Pages 55. 13½x18½ cm. Cloth. 1921. Newson & Company, Chicago.

Questions and Problems in Chemistry, by Floyd Dral, Polytechnic Preparatory Country Day School, Brooklyn. Pages VII + 177. 13x18½ cm. Cloth. 1921. Harcourt, Brace & Company, New York City.

Health and Efficiency, by John D. McCarthy, DeWitt Clinton High School, New York City. Pages VIII + 262. 3x18½ cm. Cloth. 1921. Henry Holt & Company, New York City.

Carnegie Foundation For The Advancement of Teaching Sixteenth Annual Report of President and Treasurer. Pages 204. 18½x22 cm. Paper. 1921. 522 Fifth Avenue, New York City.

BOOK REVIEWS.

General Science Instructions in the Grades, parts 1 *and* 2, *by Dr. Haner H. Webb.* 105 pages. 15×23 cm. 1921. Peabody's College for Teachers, Nashville, Tenn.

This is without question one of the most complete and comprehensive analyses of the general science situation that has ever been published. Dr. Webb has evidently made a thorough study of the situation, including all of the texts that have been written upon the subject. Without getting into the real analysis of the boo k, it is sufficient for the reviewer to say that any person wishing to know about the present status of the development of general science teaching or anything concerning the relative amount of subject matter as divided between the various sciences cannot do better than to secure a copy of this report. C. H. S.

Causes and Preventions of Fires and Explosions in Bituminous Coal Mines by Edward Steidle. 75 pages. 14½×23 cm. Paper. 1920. Government Printing Office, Washington, D. C.

This is a most comprehensive report of the causes of preventions of fires and explosions in soft coal mines that has ever been written. It is well known that the miners' safety depends very largely upon his obeying the rules governing coal mining operation. The safety first campaign among miners was developed by the Bureau of Mines. The number that have been killed by coal mine explosions either by gas or dust is enormous, and most of these explosions can be traced to carelessness on the part of some miner. There has been a remarkable decrease in coal mine accidents since the principles given in this book have been put into operation. It is most profusely illustrated, there being 117 halftone illustrations of the various phases of mine operation given. It is a book that every one interested or having anything to do with soft coal mining should have in their possession. C. H. S.

Reporting the Disarmament Conference, H. G. Wells, speaking of the Japanese situation, says: "In the long run what is happening in the schools of Japan, is of more importance to mankind than what is happening in her dockyards. At present we do not know what is happening in the schools of Japan." We do know this much. Japan is adopting American textbooks at an astonishing rate. Keio University of Tokyo, one of the largest in Japan, has just decided on Robinson, Breasted, and Smith's General History of Europe for the first year of the preparatory course, following with Robinson and Beard's History of Europe: Our Own Times (Ginn). Japan is pressing forward with the education of its common people.

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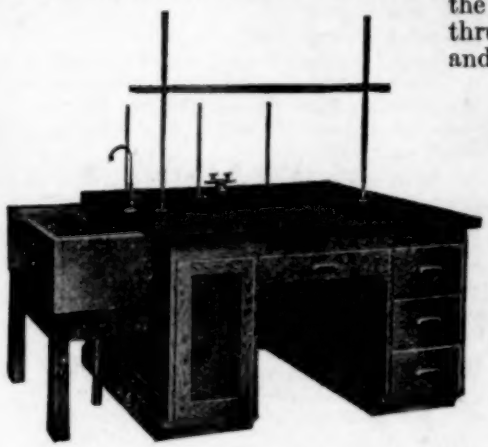

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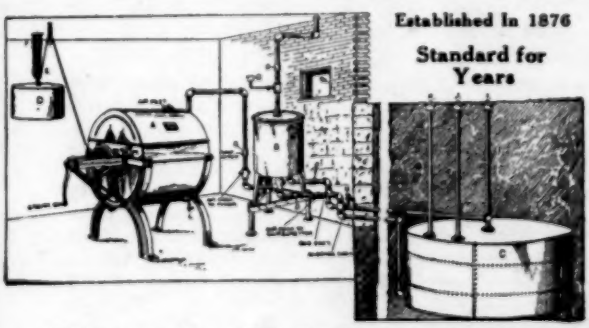

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Under this heading are published in the March and November issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. This is extremely valuable information to all progressive teachers. Is your society listed here? Names are dropped when they become one year old.

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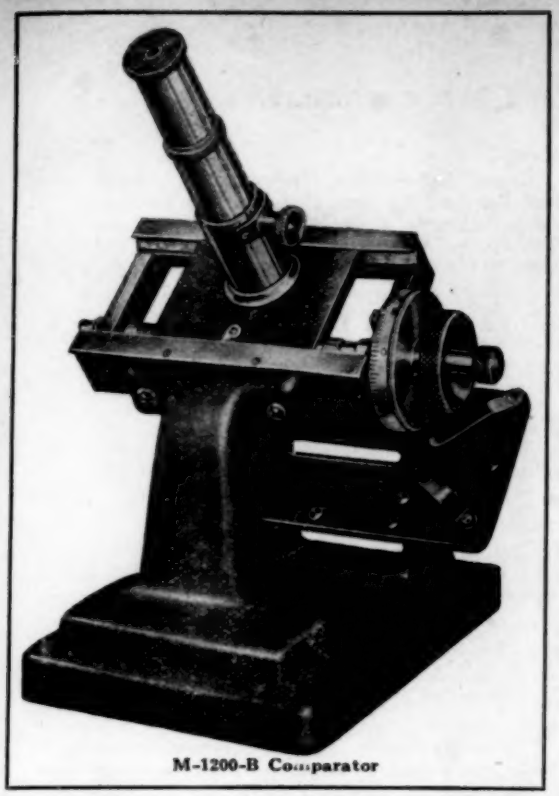

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